HARDY FRUITS

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WITH SPECIAL REFERENCE TO THEIR CULTURE IN WESTERN CANADA

BY

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DEDICATED

TO THE MEMORY OF

MY FRIEND AND COUNSELLOR

WILLIAM JOHN RUTHERFORD

1868–1930

FIRST DEAN OF AGRICULTURE

UNIVERSITY OF SASKATCHEWAN

WHOSE VISION, SUPPORT AND ENCOURAGEMENT

HAVE MADE THIS VOLUME POSSIBLE

FOREWORD

For years a text covering the culture of fruits in the Canadian North-west has been urgently needed. Growers and intending growers of fruit in many walks of life, pupil and teacher in this region, all have long desired a book that would be a source of reliable information on the growing of fruit under prairie conditions. The only sources of printed information on this subject have been bulletins, pamphlets, experimental station reports and nurserymen's catalogues, and these have been for the most part far from satisfactory. In some cases the information supplied in these publications is applicable to prairie conditions, but in many cases this is not so, and the reader is frequently unable to determine what applies to local conditions and what was intended for application in other regions. Too frequently has a hopeful beginner in the growing of fruits in this section of the country, as a result of this, been discouraged by failure through the application of information intended for a region far removed from home, and abandoned all plans to produce at least part of the fruit required to meet the needs of the family.

With a view to meeting the demand for a book on the science and practice of fruit growing with special application to the Canadian North-west, this volume has been prepared. It is the result of an attempt to place within the reach of everyone interested in fruit growing in the prairie provinces not only an authoritative treatise on the culture of hardy fruits but also a treatise on certain phases of the science of these crops. The needs of the pupil, the student, the teacher and the fruit grower have been carefully considered and as much fundamental and practical information given as space would permit.

To meet the needs of the student and teacher who are interested in the botany and in the development of fruit plants, brief notes supplying at least some of the information usually desired are included. It is beyond the scope of this book to furnish detailed discussions in this field, and those desiring more complete information on these subjects must consult good standard reference works in horticulture.

Considerable space has been devoted to a discussion of the plant and its relation to its environment. Such a discussion

may be considered out of place in a book on fruit growing but the author is firmly of the opinion that insufficient attention is usually focused on this very important subject and that the subject should be given prominence in works on the culture of plants. At least an elementary knowledge of the plant and of the plant at work is necessary for a correct understanding of the procedure in the care and management of plants, and in these chapters an attempt has been made to present a few of the simple facts upon which modern practice in fruit growing is based.

Two chapters have been devoted to a discussion of the principles of disease and pest control and of the agents used in this work. Such discussions are not usual in a book of this type but the author has deemed it wise to include them, since the needs of a diverse group are to be met and since the control of pests and diseases is fundamental in the successful culture of fruits.

Throughout the work the author has striven for simplicity, clarity, conciseness and, above all, for accuracy. At times the use of technical terms was unavoidable, but an effort has been made to give a proper interpretation of these terms. For the sake of clarity, conciseness was abandoned at times and a lengthy discussion given. Great care has been exercised to avoid inaccuracies, and the statements made can be regarded as in keeping with the known facts at the time the book goes to press.

That this book will render a service in raising the general level of knowledge of the science and practice of fruit growing in the prairie provinces of Canada and another service in advancing economic horticulture in this region is the sincere wish of the author.

CECIL F. PATTERSON.

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CHAPTER I

THE POSSIBILITIES IN FRUIT GROWING IN THE CANADIAN NORTH-WEST

WHAT are the possibilities of fruit growing in the prairie provinces of Canada? Will the growing of fruit in these provinces ever become of sufficient importance to be rated as an industry? Will it become possible for residents of this part of Canada to grow sufficient fruit of certain kinds to meet local needs or must they remain dependent in a large measure upon outside sources for all supplies of this health-giving food? Is it worth their while producing some of these fruits when supplies can be produced in less severe climates more easily than they can here? Should an attempt be made to produce an article here requiring one and one-half or possibly two units of effort when the same article can be produced by one unit of effort in districts especially adapted to fruit growing? If some of these fruits should be produced in quantities here, what kinds can be produced successfully? Is there justification for attempting to originate hardy varieties of certain fruits that cannot be grown here successfully at the present time? These are questions that are arising in the minds of many prairie people at the present time and are questions that the author is frequently called upon to answer.

To many people the fact that various kinds of fruits can be grown and are being grown in the Canadian North-west at the present time is well known. Strawberries, certain varieties of cherries, plums and crab-apples all are found in gardens in this part of Canada. By selecting varieties that are suited to northern sections and by providing the necessary shelter, those actively interested in fruit growing in this region have been able to harvest from plants growing in their own gardens an abundance of juicy, highly flavoured and well coloured fruit. It is true that the list that can be grown at the present time is not long but the variety is sufficient to make a fruit plantation interesting and an asset of considerable value. In most cases the plantations are small and no fruit is marketed but in a few cases at least sales amounting to a few hundred dollars a year have been made.

Attention is sometimes drawn to the fact that the home

fruit plantation in the older parts of Canada is passing and that people in those parts are depending more and more as the years go by on the professional fruit grower to supply fruit to meet their needs. If the home fruit plantation is not being maintained where fruits can be grown easily such a plantation cannot be expected to be a success in very northerly sections is the contention of opponents of the prairie home fruit garden. It is very true that a decline in the interest in the home fruit plantation in certain of the older parts of Canada has taken place. In going through some of these sections one finds here and there neglected orchards with only a few scattered trees that have survived the onslaughts of their enemies. In other cases the last tree has disappeared and what was once the orchard area is now part of an area being devoted to pasture or to the growing of field crops.

This apparent indifference of the owner of the neglected orchard toward the home fruit plantation is easily accounted for. It is not because he is unaware of the virtues of fruit or because he has no desire to produce at least a portion of his fruit requirements that the owner of the neglected orchard has given up attempting to maintain his fruit plantation. It is mainly because of the presence of a host of insect pests and diseases that attack fruit plants and their fruits and that are making it increasingly difficult to produce fruit that many home fruit plantations in the older parts of Canada are being neglected. Spraying; three, four, five or six times during the season is necessary in the production of good fruit in most of the older fruit-growing sections of Canada and these sprayings must be given at certain times if good results are to be obtained. Where these sprayings are not given, little fruit is harvested and the small amount that reaches maturity is of little value. To give these sprayings the owner must have a sprayer and the opinion usually held is that the fruit required can be bought more cheaply than can a sprayer and the sprayings be given. It is usually found, however, that little fruit is bought by such people and as a result the members of the family are denied the abundance of fruit to which they are entitled. The fact of the matter is that a sprayer can be purchased and the necessary sprayings given for a much smaller cash outlay than is required to purchase all the fruit that a family can use profitably. In the prairie provinces of Canada, very few enemies of fruit plants are found and most of the fruits that can be grown successfully require little spraying. Spraying will probably never become the problem

in the North-west that it has become in some of the fruit-growing sections of Canada. The decline in the interest in the home fruit plantation in Ontario, Quebec and some of the other eastern provinces is only temporary and soon there will be the revival that induced those of one, two and three generations ago to start orchards and other plantations of fruits. The West too may suffer a decline in fruit growing at some time in the future but this will neither prevent the home

FIG. 1.—BLOSSOM TIME ON THE PRAIRIES
This apple orchard is located at the Dominion Experimental Station, Rosthern, Saskatchewan. It is one of the oldest plantations in this province.

fruit plantation from becoming well established and serving a very useful purpose in the agriculture of the prairie provinces nor deter the ambitious home builder from taking advantage of an opportunity to produce some of the fruit required by the family.

As to the relative costs of producing fruit on the prairies and of producing similar fruit in fruit-growing sections of the country one must admit that greater effort is required under prairie conditions than is required under more favourable conditions to produce a given article. Even though this is true the actual cost of producing a small amount of fruit at home on the prairie is not necessarily greater than that required

to produce a similar amount elsewhere and it may be economical to produce such fruit under the more difficult conditions. If every hour of labour on the farm could be made to yield a good return in dollars and cents it would probably be more economical to buy the necessary supplies of the fruits mentioned above than to grow them. But in how many cases does every hour of labour on the farm yield a tangible return? In very few cases is this true. On most farms there are many hours of labour expended each year without a return of any description save weariness and a whetted appetite. In most cases the few fruits that may be grown in this province and that could be used to advantage can be produced without any additional cost in the operation of the farm beyond that required to obtain the plants at the beginning. Any attention that the plants required could be given at odd times when other work was not pressing and when in all probability the hours would not be profitably employed. The fruit obtained in such cases would represent a clear saving of the amount that would otherwise be paid out for such fruit and it would be much fresher and have a greater value than the imported product. There are many cases too where people fail to buy fruit for one reason or another and in such cases a home fruit plantation would result in the family having a supply of this healthful food that it would not have otherwise.

Is it worth while attempting to produce additional varieties of fruits for Saskatchewan and is there justification for the spending of money on such a project? It is certain that the people of Minnesota and South Dakota have no regrets that money and effort were spent producing hardy fruits for those States. The benefits derived from their work extend far beyond the boundaries of these States and fruit growers even in the prairie provinces of Canada owe them a debt of gratitude for a number of varieties that have a prominent place on lists of fruit recommended for those provinces. Even if those in the Canadian West at work on the problem at the present time succeed in introducing only a few hardy varieties of fruits and make a well-rounded home fruit plantation in the prairie provinces possible, the cost will be more than justified. Whatever the attitude of the majority of people of this province toward this matter is at present, it is certain that the time will come when the memories of those that conceived a province with its fine home fruit plantations and that were responsible for the initiation of effort to make such plantations possible will be honoured for the contributions they have made to prairie horticulture.

In most of the hardier fruits there is great opportunity for development. The apple, plum, cherry, raspberry, gooseberry and strawberry all present promising material for the evolution of hardy varieties possessing the desired qualities. Progress is being made much more rapidly in some fruits than in others and already considerable variety in certain kinds is found. Though probably distant, the day will come when very fair varieties of the standard apple sufficiently hardy to be grown under average prairie conditions will be

FIG. 2.—FRUITS IN VARIETY IN A PRAIRIE GARDEN

This is part of the fruit plantation of W. D. Willoughby, Parkside, Saskatchewan, in Township 49. Loganberries and blackberries have matured in this plantation.

numerous. From the cold-enduring Siberian crab-apple and some of the hardy standard apples will be evolved apples with sufficient hardiness to survive western winters and with the size and quality of some of the much-prized standard apples. The plum will show marked improvement and selections of the Canada plum together with hybrids between it and the Japanese plum, a much-grown and valued commercial plum, will give a long list of hardy plums possessing the maximum size and quality consistent with the necessary hardiness. In cherries varieties of the sour cherry derived from Russian types of the morello, in addition to new and valued varieties in the present group of hybrid cherries, will be grown. The

hybrid cherries of which Champa, Oka and Tom Thumb are recommended varieties will be greatly improved and a much longer list will be available for planting. The native pin cherry will be found to contain valuable material and named varieties of this fruit will be found on the list of hardy fruits for the prairie provinces a few years hence. Hardier varieties than now exist, with the requisite quality, will appear in the strawberry, gooseberry and raspberry. Native material will contribute much in the production of suitable varieties of these fruits. The downy shadblow and saskatoon will yield varieties worthy of propagation and cultivation. Some of the other native fruits also will give up varieties that will have a place in the home fruit plantation in this province. A new day in fruit growing in western Canada will be ushered in and future generations on the land in these parts will have variety and quality in home-grown fruits little dreamed of at the present time.

As to the extent that fruit growing will be practised in the Canadian West, time only will reveal. There are probably few farms on the prairies on which vegetables are found to do well that are incapable of producing fruit. What is being done on a relatively small number of farms in the prairie provinces will doubtless be done on many others. The possibilities of fruit growing in the West are being realized more and more each year and even the next decade will witness a great increase in the amount of fruit produced on the prairies. It is not unlikely that home fruit plantations will be as common in the not distant future as vegetable gardens are now and that commercial fruit plantations will be much more numerous than at present.

Eighty years ago fruit growing was in much the same stage in Minnesota that it is in the prairie provinces at the present time. Very little fruit was being grown in Minnesota at that time. Plums, raspberries and blackberries were found growing wild but the fruits of these were of poor quality. Many of the settlers that had come from the New England States and who were accustomed to growing their own supplies of fruit made attempts to establish fruit plantations from imported plants in the State of their recent adoption. Their efforts were in vain as their plantations were wiped out by the first severe winter. It soon became evident that new varieties to meet Minnesota conditions were necessary. In a few cases seeds obtained from other places had been sown and it was found that some of the seedlings obtained possessed the necessary hardiness. As a result large quantities of seed were sown, and

from one lot of apple seed sown by Peter Gideon came the Wealthy apple, a variety that is still considered one of the best of its class. Many other excellent varieties of fruits, possessing the necessary hardiness, were obtained and since 1900 fruit growing has been an industry of considerable importance in that State. Experiences in South Dakota have not been unlike those in Minnesota. There, too, most of the hardy fruits being grown today are the product of effort initiated as a result of failure to grow successfully the older varieties. What has happened in Minnesota and South Dakota is happening and will continue to happen in the prairie provinces of Canada. The evolution of the industry will probably be slower in these provinces than it has been in Minnesota and South Dakota owing to the less favourable climatic conditions, but the time will come when the fruit plantation in western Canada is no longer a rarity and is considered an indispensable part of the farm garden at least.

The vision the author has is one where the home fruit plantation will be considered by everyone to be an essential part of a western farmstead plan and where small commercial plantations of certain fruits will be found supplying fruit to the urban population. A visit to the strawberry patch and to the raspberry patch, as often as taste and appetite dictate, will be the privilege of every farm girl and farm boy. No longer will young men and young women who have never seen an apple or a plum on a tree be found on the farms of these provinces. The imports of fruit *per capita* will be as great as or greater than they are at present and the consumption will be much increased. Many people in isolated districts and elsewhere that are not receiving their share of fresh fruit at present will have an abundance. Those that are using fresh fruit now in moderate quantities will be greater consumers of this healthful article of diet. The people of the prairie provinces will not be vegetarians living mainly on fruit but will be enjoying a more normal diet than at present, will have many of the privileges that people in fruit-growing sections enjoy and will be using freely a product of the land that for ages has refreshed man and has given him renewed strength for his daily tasks.

CHAPTER II

GENERAL METHODS OF PROPAGATING FRUIT PLANTS

VARIOUS methods are employed in the propagation of fruit plants. While capable of being propagated by different methods each fruit is found to be better adapted to propagation by one method than by another. The method usually employed is one that meets well the needs of the plant concerned and that is consistent with the necessary low cost of propagation.

The methods used in the propagation of fruit plants are either (1) sexual or (2) asexual. A sexual method is one in which the male and female organs of the plant play a part. These organs play a most important part in the production of seed and the propagation of plants by seeds is therefore propagation by a sexual method. Asexual methods differ from the sexual method in that the flower plays no part whatsoever in the process. Asexual propagation is the making of increase by vegetative means—the use of some vegetative part of the plant such as the root, stem, leaf and bud. These parts are employed in different ways and the most important methods embodying their use in the propagation of fruit plants are outlined below. Asexual methods are necessary in making increase in all named varieties of fruits, where the varieties are to be preserved, and by the fruit grower they may be considered more important than the sexual method of propagation by seeds.

PROPAGATION BY SEEDS

This is one of the simplest methods of propagating fruits. Seeds are produced freely by nearly all temperate fruits and in most cases these will germinate readily following treatments that can be given easily by anyone interested in the propagation of fruits in this manner. This method is not satisfactory in most cases, however. Since crossing takes place freely among varieties and since crossing is requisite to fruitfulness in some kinds, named varieties of fruits cannot be expected to come true to variety from seed. Further, named varieties are not pure for certain important characters

and even if varieties were self-fruitful and did not cross great variation in the seedlings would be found. It is a fact that apple seed will produce apple trees; raspberry seed, raspberry plants; and strawberry seed, strawberry plants; but the chances are that no two plants produced by these seeds will be identical with the variety from which the seed came. In most cases great variation in the seedlings obtained is found and seldom does a seedling either surpass or equal the better of the two parents in named varieties. In the sour cherry (*Prunus cerasus*) the variation is probably less marked than in most other temperate fruits and it is sometimes said that varieties of this cherry will come true from seed but this method is not to be recommended even for this fruit. New varieties are usually obtained from seed and while every seedling is a new variety, probably not more than one in ten thousand grown may be sufficiently better than other varieties to warrant its propagation.

Uses of Seeds.—Seeds have important uses, however. In the cases of apples, plums, cherries and other tree fruits, seedlings are necessary in the propagation of named varieties. Seedlings are used as stocks on which to bud and to graft named varieties and without such seedlings the propagation of named varieties of certain tree fruits at least would be extremely difficult. To the fruit breeder and to the originator of new varieties seeds are indispensable. In the seeds are the tiny plants that have resulted either from his controlled pollinations or from natural pollinations and that may produce the improved varieties that are desired. Where fruit trees are grown merely as ornamentals, variety is seldom a consideration and the plants in such cases are usually grown from seed because this is usually the least expensive and the least troublesome method of propagation.

After-ripening of Seeds.—Seeds of most hardy fruits must undergo after-ripening before germination will take place. After-ripening is a process in which certain changes that are necessary antecedents to germination, but about which little is known, are effected in mature seeds of certain plants. These changes take place under certain conditions of moisture and temperature. Exposure of the seeds in a moist condition to temperatures a few degrees above freezing for a shorter or longer period usually brings about these changes. Temperatures between 36° F. and 44° F. are the most effective in after-ripening the majority of seeds demanding this treatment. Temperatures much above this range are without effect in most seeds. It has been shown that temperatures below the

freezing point are without effect in the after-ripening of seeds but the experience of the author indicates that temperatures not far below the freezing point have some virtue in bringing about these changes in certain seeds. Holding the seeds dry and at room temperature is beneficial in some cases while in other cases this treatment is harmful.

After-ripening of Seeds in Nature.—After-ripening is effected in Nature through the seeds remaining in contact with the moist earth on which they have fallen from the plants and being subjected to suitable temperatures at certain seasons. Suitable temperatures at the ground surface prevail only during the fall and early in the spring before growth begins but these two exposures are sufficient to bring about the required changes in many cases. In other cases these are not sufficient and additional exposures to these conditions are necessary. The effect of these exposures is cumulative to some extent at least and the amount of after-ripening accomplished in one year remains and the after-ripening of the second year begins where that of the first year ended. In certain seeds the process is not completed by Nature until the fourth or fifth year.

After-ripening of Seeds artificially.—Under certain artificial conditions after-ripening can be effected in a short time. It is common practice to hold the seeds concerned under suitable conditions and at suitable temperatures continuously until the process is completed. In some cases the seeds that have been separated from the flesh are mixed with sifted sand, which is subsequently well moistened with water, and the mixture placed in a suitable container such as a flower-pot. Exposure is then made to a temperature between 36° F. and 40° F. The sand is kept moist during the period of exposure. The time required is usually from two to six months at such temperatures. At the end of this period the seeds are separated from the sand and are sown immediately in the ordinary way where germination may take place. In other cases the seeds are placed in damp moss or damp peat in a suitable container and are held at a temperature of 40° to 45° F. When fully after-ripened the seeds will germinate on the medium and those showing germination are removed before much development takes place. These are placed at once in soil under suitable growing conditions. The remainder are left to complete after-ripening and to germinate and are transferred to growing conditions as they show signs of germination. The former method is practicable with a large quantity of seed while the latter is usable with a limited

amount of seed only. The lower range is maintained in the former case to retard the germination of seeds that have completed their after-ripening.

Where a temperature between 36° and 40° F. cannot be maintained for long periods and where a suitable place indoors to start the plants cannot be provided the seeds should be after-ripened out of doors. The simplest but probably the least satisfactory method in this case is that of sowing seeds

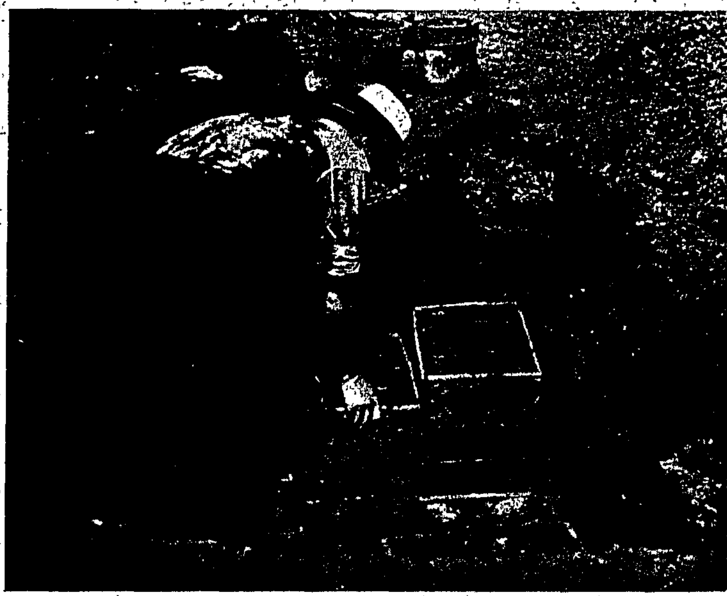

FIG. 3.—A PIT FOR THE AFTER-RIPENING OF SEEDS

The seeds are mixed with moist sand or moist soil and placed in boxes and pots that are buried about three feet below the ground-surface in the autumn. The seeds are planted in the open in the spring.

in moist soil in the open in the fall, where the plants can be grown for a year or two. If the soil is kept moist fair results may be obtained but in some cases only a small germination will be obtained the first spring. Later germinations will take place in such cases if the seeds are not disturbed, and a fair stand may be obtained eventually.

A better plan for the outdoor treatment of seeds than that outlined above and one that has been used very successfully by the author for eight years is a plan involving pitting. In this case the seeds requiring after-ripening are placed at a depth of from two and one-half to three and one-half feet

below the ground surface late in the autumn and are left there until late in the spring. A well-sheltered location should be chosen for the pit. A mulch of leaves or of straw to a depth of six inches or a foot as a covering for the soil is to be recommended. The seeds may be sown in moist soil in shallow boxes, such as greenhouse flats, and the boxes placed at the depth mentioned or they may be mixed with sifted sand and the sand and seed mixture placed in flower-pots or other containers at this depth. After being placed in the containers the material should be well moistened with water. In the former case the seed is sown thinly enough to permit the seedlings to grow for one season at least without being disturbed. The boxes are merely taken out of the pit late in the spring and placed on the north side of a building until the seedlings are showing through the soil when full exposure to direct sunlight should be given. In the latter case the seeds are separated from the sand as soon as they are taken from the pit in the spring and are sown at once either in boxes or in the open ground. The use of a frame is frequently advantageous. It is advisable to remove the seeds from the pit and to sow them early in the spring but they may be left there until late in May provided the ground at the level of the seeds remains frozen. The removal of the mulch early will hasten the departure of the frost from the ground and will permit planting at the normal time. Treated seeds must not be held long after thawing as germination takes place in after-ripened seeds at low temperatures and seeds with sprouts are difficult to transfer from sand to the open ground without injury. The advantage of placing the seeds in a pit over sowing them direct lies in the extended periods of exposure to suitable after-ripening temperatures insured by the sub-surface level.

Separation of Seeds from Flesh.—In all cases the seeds or so-called seeds or pits should be separated from the flesh before being sown or subjected to after-ripening conditions. Allowing the flesh to rot is an aid in effecting this separation in some cases at least. The fruits, either in the fresh condition or rotted, are crushed in a pail or other vessel and sufficient water is then added to fill the container. Sound seeds are usually considerably heavier than the pulp and separation is allowed to take place by gravity. The pulp and light seeds may be floated off and the good seeds will be found in the bottom of the container. A sieve may be of material aid in effecting separation. Small amounts of fruit may be crushed in a kitchen strainer with a mesh sufficiently fine to retain the

seeds but coarse enough to permit the pulp to escape. The skins can then be made to float away. By using water freely the operator can effect good separation by this means.

After being separated from the flesh the seeds or so-called seeds should be treated in the manner demanded by the species. "Seeds" of the strawberry for instance which do not require the low-temperature and moisture treatment, should be spread out to dry and after drying they should be placed in a paper bag and held until sowing time in a cool room.

FIG. 4.—FRAMES CONTAINING SEEDLINGS

After-ripened seeds are usually sown in frames in a well sheltered place outdoors.

Plum and cherry pits, on the other hand, should not be allowed to dry and should be brought in contact with a moist medium at once. Seeds of the saskatoon require after-ripening but are benefited by a drying treatment after being separated from the flesh of the fruit. Seeds of other kinds require their special treatments too and the grower should be guided, when germinating seeds, by the findings of investigators in this field.

BUDDING

Uses of Budding.—Budding is a very popular method for the propagation of tree fruits. Named varieties of apples,

plums, cherries and other tree fruits are usually propagated in this way and a large percentage of the plants of these fruits used are budded stock. It is a rapid and successful method of propagating such fruits in the hands of experienced budders and the plants resulting usually make very satisfactory trees.

While its chief use is in the propagation of tree fruits budding is used also to some extent in top-working young trees of these fruits. Trees of undesirable varieties frequently have their tops changed to desirable varieties and this is done by a process known as top-working. The branches are removed and these are replaced by new branches produced either by buds (in budding) or sections of shoots (in grafting) that are applied in the proper way to the stubs left when the old branches are removed. The most common method of top-working is by grafting which will be outlined later but budding may be used successfully for this purpose in certain cases.

Budding Defined.—The operation of budding is the transfer of a bud with bark, but with very little wood attached, from one plant to another and applying it to the latter in such a way that union will take place. The plant to which the bud is applied is known as the "stock". Stocks used in budding are nearly always of the same kind of plant as the bud. For buds of named varieties of apples, stocks of apple or of crab-apple are used. For buds of named varieties of plum, stocks of plum are used, and for buds of named varieties of cherry, stocks of cherry are used. In propagation by budding, seedlings are used as stocks and the bud is applied to the seedling at or near the ground surface. Union takes place and the bud receives nourishment from the stock. From the bud applied, develops a shoot that eventually becomes the trunk and the top of the tree. The only part of the seedling used as a stock that remains is below the point of union and the point is usually at or just below the ground surface in the transplanted tree. The base of the stem and root system, therefore, is of the stock and the part above ground is of the named variety that was budded. The roots which make up the greater part of the stock take up from the soil water and salts to meet the requirements of the entire plant and receive from the named portion above ground sufficient organic materials manufactured by the green parts to supply their needs. Even with this exchange of materials each retains its identity throughout the life of the plant. The part above ground produces fruit of the named variety budded

and the part below the ground retains the characteristics of the stock.

In top-working, stocks are usually well-established trees that are more or less fully developed. The branches are cut back severely and the buds are placed just below the cuts. From the buds that unite with the bases of the branches new branches develop and these fruit in due time. The part above the point of union and the part below the point of union in this case also retain their identities throughout the life of the plant.

Character of Seedlings used as Stocks in Budding.—The seedlings used as stocks in budding are small but should be vigorous. Plants with stems about the size of a large lead pencil near the ground level, and that have made fairly rapid growth, are ideal for use in budding. Two or three seasons' growth from seed is usually sufficient to bring the plants to the stage where they are suitable for budding. Much depends upon the environment of the seedlings as to the rate at which growth takes place but those of apple and cherry are frequently ready for budding one year earlier than those of the plums. The seedlings should be so spaced in the nursery row that the operator can work unhampered on each tree.

Time for Budding.—The usual time to bud tree fruits in the Great Plains region is during the latter part of July and the early part of August. Much depends, of course, upon the condition of the plant and upon the season. Budding should be performed while the bark can still be separated readily from the wood and before the tissues concerned lose much of their sap. Suitable buds are necessary and it must be done when these are obtainable. Plums and cherries can usually be budded to advantage late in July, or during the first week in August at the latest, while apples may be budded successfully usually any time during the first two weeks of August. If ordinary budding is attempted later than the times mentioned the bark may be found difficult to separate from the wood and when this condition obtains the operation is tedious and the results uncertain. A special form of budding, however, may be practised late in August and during much of September.

Equipment required in Budding.—Little special equipment is necessary in budding. The important articles are as follows: a sharp knife, wrapping material, wax and bud-sticks. Special budding-knives are obtainable and are to be recommended for use but a good jack-knife may be employed by the beginner. Ordinary cord or some similar material is necessary for wrapping the stem or branches at points where

buds are to be applied. Raffia, a wood fibre, is frequently used and this is very satisfactory. Small rubber bands are probably better than any other wrapping material that may be used as they are easily applied and cannot injure the plant. The stem of the plant that has been budded continues to increase in diameter and cord and raffia may damage the plant if these are not cut at the proper time. Rubber bands stretch more as the stem increases in size and they lose their elasticity and become dead about the time wrapping material is no longer needed. Bud-sticks of the named varieties to be budded are required. These sticks are of sturdy growth made the same season. In the axil of each leaf, just above the point of leaf attachment, is found a bud and these buds normally open the following spring and give rise to leaves, flowers and shoots. The buds to be used in budding should be well developed and in some cases it is necessary to discard those near the tips of the shoots because of immaturity. The leaf-blades and the tips of the leaf-stalks are removed and the remainder of the stalks are left to serve as handles for the buds. A bud-stick is shown at B in Fig. 5. The bud-sticks must be kept moist and while budding is in progress they should be carried in a pail containing damp moss.

While usually considered not essential, a wax heater is frequently a valuable asset in budding. The purpose of the heater is to keep the paraffin or grafting wax being used in the fluid condition. High temperatures are not required and an oil burner supplied with a cup to contain the wax meets the requirements well.

Shield-budding.—Various forms of budding are practised but the most common and the most practicable form is that known as "shield". This form is used very extensively and is used exclusively by many propagators. The operation of shield-budding is easily performed and it is not unusual for 90 per cent of the buds applied to unite with the stocks and to develop into the sturdy shoots desired.

How Shield-Budding is Performed.—The details of the method of shield-budding are shown in Fig. 5. An apple seedling in condition for budding is shown at A. This constitutes the stock. The bud is applied as close to the ground surface as is practicable. A plan frequently followed is that of removing some of the soil from around the base of the stem and to make the necessary incisions on a level with the surface of the soil. In dry years it may be worth while banking soil slightly around the bases of the stems early in the season and removing this at budding time. A "T"-shaped incision as

shown at C is required. This incision is made through the bark with a sharp knife. The next step is to prepare the bud for application. From one of the bud-sticks prepared previously, and as shown at B, a bud is taken and with the bud is taken a shield-shape piece of bark with little wood attached. A cut is made through the bark about one-half inch below the bud with a sharp knife. The blade is then drawn upward between the bark and the wood and about one-fourth to three-eighths of an inch above the bud the cut is terminated. The knife is

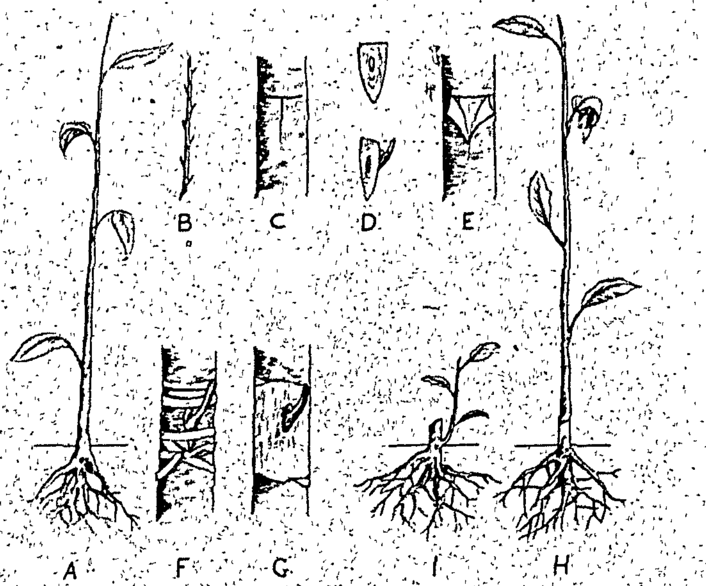

FIG. 5.—SHIELD-BUDDING

withdrawn and a cut is made through the bark, at right angles to the stem, at this point. This results in the lower end of the bark attached to the bud being pointed and the upper end square. A small amount of wood will be found attached to the bark especially at the rear of the bud but attempts should not be made to remove this as its presence is advantageous. The bud with the adhering bark may be cut with one continuous movement of the blade of the knife and with a little experience the operator will be able to do this. A bud cut in this manner is shown at D and this bud is ready for insertion in the "T"-shape incision shown at C. The corners of the bark are then turned back as shown at E and the bud

that has been properly prepared is inserted. The upper end of the bark which has been cut square should fit snugly against the horizontal cut of the "T". The corners of the bark of the stock are then brought in contact with the bark attached to the bud. Two or three wrappings either of common cord or moistened raffia or thin rubber bands, each above the bud and below it, are used to hold the bud in place and to make close contact between the surfaces that must unite. The tied bud is shown at F and the budded plant at H. The ends of cord and raffia are tied in the ordinary way. The rubber band to be used should be cut leaving a long piece of thin rubber. The first end is held by the first wrapping passing over it and the last end is slipped under the last wrapping. Considerable tension should be brought on the rubber. This completes the operation of budding.

It is common practice to bank soil around the base of the tree immediately after the bud has been applied. Sufficient is used to cover well the area occupied by the bud. This treatment is given to protect the tissues that have been cut and to increase the percentage of successful buds. The treatment is helpful, without doubt, particularly when the atmosphere is very dry, and its use is to be encouraged.

Coating the area in the region of the bud with wax is being practised by some budders as a substitute for banking with soil. Either very soft grafting-wax or melted parawax is reported to be satisfactory. Good results have been obtained from the use of this treatment and it is probable that it will replace banking with soil to a large extent. Wax applied to the area is shown at G in Fig. 5.

The use of a covering for the buds appears not to be necessary in all cases. Ninety per cent take in apples has been obtained in Saskatchewan without the protection mentioned above. In this case a covering would probably not have increased the set of buds appreciably. This record might prove difficult to equal and the use of a covering will be found to increase the set in the majority of cases. Even by the budder that despises special aids in budding, either soil or wax should be used to insure a high percentage of successful buds.

When the operation has been successful union between the bud and the stock takes place in a short time. Where either cord or raffia has been used as a wrapping material the strands should be cut in about three weeks' time to prevent "choking" which would take place as a result of the stem continuing to increase in size late in the season. Where rubber

bands have been used this is unnecessary. No further treatment is required until spring.

In the cases of tree fruits the buds remain dormant until the following spring. About the time growth begins in the spring the buds are examined for development. If the buds show no indication of expansion at this time additional treatment should be delayed until assurance that union has taken place has been obtained. As soon as development in the bud becomes evident the stem of the plant should be cut off about one-half inch above the bud. The cut is made at the line shown just above the bud in H. The wound thus made should be covered at once with either grafting wax or melted parawax. From the bud applied will develop the portion of the plant that is to be above ground. A plant treated in this way and with a short shoot that has developed from the bud applied is shown at I in Fig. 5.

Great care must be exercised when performing the operation of budding, and the work should be done as speedily as possible. The tissues exposed by the various cuts made are very sensitive to drying, and must not be left unprotected more than a few seconds. This is true especially on a hot, dry day. The various steps in the operation should be made, therefore, as rapidly as circumstances will permit to prevent undue drying of these delicate tissues. The necessity of proper placement of the bud must not be overlooked, and the directions given above should be followed carefully.

Dry-budding.—This form of budding has a distinct advantage over shield-budding in that it can be practised long after the normal budding season is over. During the normal budding season and when the bark separates readily from the ~~wood~~ this form of budding may be less satisfactory than shield-budding but after the bark begins to tighten dry-budding alone can be depended upon to give even fair results. It has been reported to be more successful than shield-budding at all seasons in the plum. Its chief use, however, is that of extending the season of budding and permitting the successful application of buds during late August and September.

The details of the method are shown in Fig. 6. The first step in the operation is that of slicing the bark from the stock over a length of one to one and one-fourth inches. The cut is made downward with a sharp knife and the bark only is separated from the main portion of the stem. This loose bark is then cut horizontally three-fourths of the way down and only the lowest portion left as illustrated at A. The bud is prepared in a manner similar to that in shield-budding as

shown at B. The first part of the cut is made in a downward direction, however, to expose cambial tissues on the outer side. The bud is then inserted as shown at C. The portion of loose bark attached to the stem is brought in close contact with the bark attached to the bud and either a rubber strip or moistened raffia is used as wrapping material to hold bark and bud in place as shown at D. A coating either of soft grafting-wax or of melted parawax completes the operation as shown at E.

Effect of Budding on Varieties.—Throughout the life of the plant resulting from this budding the two distinct varieties which are in close contact retain their identities. Below the

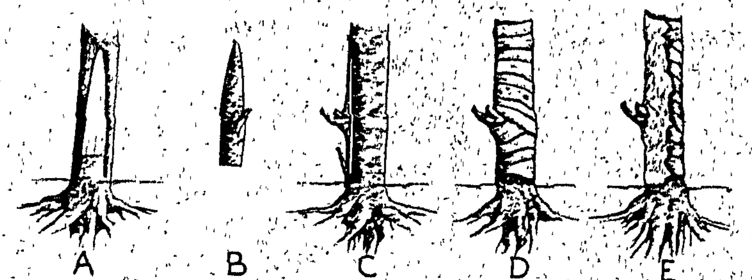

FIG. 6.—DRY-BUDDING

point of union is the stock, and above the point of union is the part produced by the bud. Each remains as it was at the time of budding and is not appreciably affected by the other except in special cases. A bud of McIntosh apple, for instance, will produce a top that will yield McIntosh apples regardless of the variety of apple used as a stock. This is a case of mutual co-operation working for the benefit of both but allowing the individuality of each to remain.

GRAFTING

Grafting defined.—Grafting is the operation of applying a section of a shoot bearing buds to a suitable stock in such a manner that union will take place. It is practised in the propagation of tree fruits, in top-working, and in repairing

trees that have been girdled or partially girdled by rabbits and mice.

The Scion.—The section of shoot used in grafting is referred to as the scion. The shoot concerned is of the previous season's growth and bears at least one bud at each joint. For most forms of grafting the scion should be approximately six inches in length and about three-sixteenths of an inch in diameter. Scions either smaller or larger may be used, however. In most cases the scion to be applied must be of the same kind as the stock though in a few cases a difference between the stock and scion may obtain.

The Stock.—The stocks used in grafting differ considerably. For certain forms of grafting the stocks are usually small seedlings similar to those used as stocks in budding. In some cases short sections of roots are used. In other cases well-established trees that have reached the fruiting age become stocks. In all cases stocks should be in a healthy condition and free from frost injury.

Preparation of the Scion Material.—Scion material for use during the winter and spring should be cut late the previous autumn and placed in cool storage. It is very important that scions be free from frost injury and in a dormant condition when applied. Scions taken during the winter and early in the spring may have been injured by low temperatures and be of little value. To insure the availability of uninjured material the operator cuts the shoots to be used for scions either late in the autumn or early in the winter before heavy freezing occurs. In cool storage this material remains dormant and is in good condition for use at grafting time. Where it is to be used during the winter the scion material may be packed in damp moss and placed in a cool storage where the temperature remains below 40° F. For use in the spring this scion material may be buried in damp sand or damp soil a foot below the ground surface outdoors. In this case the material should be cut from the trees just as winter is beginning to set in and buried at once. A few inches of straw or other litter should be used as a covering for the area in which the scion material is buried to hold the frost for considerable time in the spring and to keep the buds dormant until the scions are used.

Polarity in Grafting.—It is very necessary that polarity be observed when grafting is being done. If the grafting is to be successful the ends of the scion must have the same relation to each other and to the plant as they had previously. The apex of the scion, or the end that was the more distant from the base of the plant formerly, must be the more distant in

the grafted plant and the base of the scion must be toward the base of the grafted plant. When this condition obtains and when the operation has been ~~performed properly most of~~ the grafts will be successful, but if the scions are reversed the grafting will be a failure, excepting in very special cases, regardless of the care exercised by the operator.

Important Forms of Grafting.—The most common forms of grafting are as follows: whip, bark, cleft, side and bridge. Whip-grafting is employed in the propagation of certain tree fruits, particularly the apple, and also to some extent in top-working small trees. Bark-, cleft- and side-grafting are used chiefly in top-working well-established and fruiting trees. Bridge-grafting is employed in repairing girdled or partially girdled trees.

Whip-grafting.—This form of grafting may be practised either on the stem or on the root of a plant. It is desirable to have the stock about the same size as the scion or only slightly larger. If the scions were one-fourth of an inch in diameter the stock could be up to one-half inch in diameter but should not be larger than this.

Stocks for Whip-grafting and their Preparation.—In the propagation of plants by this method the nurseryman uses either seedlings or short sections of small roots as stocks. In the former case the seedlings are cut back severely and the scions are applied, one to each stock, at the base of the stem just above the crown as shown at A in Fig. 7. Root sections four to six inches in length and about the same size as the scion or a little larger are used in the latter case as shown at B in Fig. 7. The stocks are taken up late in the autumn and are heeled-in, in damp sand or in damp soil in a cool storage where they will remain dormant. In the case of the seedling stocks the tops may be cut back to within six inches of the bases of the stems at digging time. Root sections to be used should be made a little longer at digging time than required to permit the cutting away of portions at the ends at grafting time. The stocks must not be allowed to dry and the sand or soil covering must be kept reasonably moist during the storage period.

When being used for top-working small trees, whip-grafting is usually performed a short distance from the ground. The plants used as stocks must be well established and their stems should not be much more than one-half inch in diameter. The stems are usually cut off a few inches from the ground and scions that were taken in the autumn previous, and that have been kept dormant in the ground over winter, are applied at this point.

Steps in Whip-grafting.—The important steps in whip-grafting are shown in Fig. 7. The stock is prepared by making a long diagonal cut at the required point with a sharp knife. Near the edge at the long side of the slope a slit about one-half inch in depth or a little more is made and this should be made at an angle and toward the centre of the stock. The lower end of the scion is prepared in the same way excepting that the slit is made near the short side of the slope and toward the surface of the scion. The scion and the stock prepared in this manner are shown at C in Fig. 7. These are then fitted together as shown at D. The tissue that is responsible for the union is known as the cambium and the cambium of the scion and the cambium of the stock must be

FIG. 7.—WHIP-GRAFTING.

in contact over as great an area as possible. Since these tissues lie just below the bark the scion and stock must be brought together in such a way that contact is made on one side at least. These tissues are a very thin layer, and if the inner bark of the scion is brought in contact with the inner bark of the stock the position should be satisfactory. Setting the scions at a slight angle, so that the cambium of the scion crosses the cambium of the stock and so that contact between these tissues at one point is assured, may increase the percentage of success in this form of grafting. The scion should have three or four buds at least and the lowest bud should be just above the sloping cut and on the side where contact between the cambium of the scion and the cambium of the stock is the better. The stock and scion are then tied together firmly by wrapping with either raffia or waxed cord and care must be taken to prevent displacement. The tied graft is

shown at E. The point of contact and the sections close to it are then covered with melted wax to prevent drying of the tissues directly concerned in the process of unification. A completed graft is shown at F.

Whip-grafting is performed at two seasons. When being employed for purposes of propagation it is usually performed during the month of February. When being used in top-working, whip-grafting is usually done during May in the prairie provinces of Canada. The time varies to some extent with the section even of a province and the best time is just after the leaf buds unfold and before the flower buds open. This period is usually between May 15th and May 25th at Saskatoon.

After being made and waxed as directed the grafts require no special treatment. Those for propagation and which are made in February should be packed in damp moss at once and placed in cool storage where the temperature will remain sufficiently low to prevent growth. Suitable temperatures are those between 38° and 42° F. At these temperatures the stock and scion will unite but will remain dormant. The moss must be kept moist at all times. The grafts made in February should be planted out of doors early in the spring. Shoots should be allowed to develop only from the scions and all those springing from the portion below the point of union should be removed as soon as possible after they appear.

Bark- and Cleft-grafting.—Bark- and cleft-grafting are employed mainly in the top-working of trees that have reached the fruiting stage. In this process the tops of trees of given varieties are changed to other varieties. For one reason or another the grower finds it necessary at times to make this change and top-working is preferable to cutting down the trees concerned and beginning with small plants of the desired varieties. Fruit of the desired varieties used may be obtained in two or three years after the top-working has been done while young plants of most varieties will not fruit to any extent until five or six years or more after being planted.

As stated above top-working is usually done during May and these forms of grafting should be performed, therefore, at this time. From May 15th to May 25th is the best time in the average season. The scion material should be taken the previous autumn, just before the winter sets in, and buried in the ground about one foot below the surface. This material is left in the ground until wanted and is then taken out and used at once.

Working over the top of a tree of one variety to another variety is usually spread over two or three years. In a large tree the operation should take three years while in trees of medium size it may take only two years. From one-third to one-half of the branches may be grafted the first year and the remainder grafted either the second year or divided between the second and third years. Trees of small size may be done in one year safely.

These forms of grafting may be performed on branches of various sizes. It is advisable to use branches not larger than two inches in diameter where possible but those larger than this may be used where necessary. Those down to three-fourths of an inch in diameter may be grafted successfully using these methods.

While there is no fixed point on a branch where the graft should be made it is desirable to have it near the base of the branch concerned. Much depends upon the size of the tree, as to the location of the grafts, but the distance between the base of the branch and the place where the cut is made will vary from one to three feet under most conditions.

The branches to be used are cut square across at the desired point just before the grafting is to be done. It is important to have the bases of the branches left in good condition and as a measure to prevent the splitting of these the operator usually cuts off the branch first at a point a few inches beyond where the graft is to be made. Later a cut is made farther back and at the desired point.

The Cleft-graft.—The steps in cleft-grafting are shown in Fig. 8. A branch cut off and ready for grafting is shown at A. The end of the branch is split across the middle as at B. This split or cleft should be made only deep enough to hold properly the scions to be inserted. It is seldom necessary to make a cleft deeper than two inches. The direction of the split should be horizontal in the cases of branches not in vertical position. Where the branch is vertical the split may be made in any direction. The scions are then prepared as shown at C. These scions should be four to six inches in length and they are sharpened on two opposite sides in such a way as to make long sloping cuts. A long thin wedge results and this wedge should be slightly thicker on one side than on the other. The scion should be made so that a bud is present a short distance above the base of the wedge and on the thicker side. The scions are then inserted in the cleft as at D. The insertion of a small metal or wooden wedge in the cleft may be necessary to keep the halves apart and to permit the

proper placement of the scions. The thicker side of the wedge on the scion is placed at the outside. The scion is set at a slight outward angle to the branch to insure contact between the cambium of the stock and the cambium of the scion at some point and is placed sufficiently far down to bring the base of its wedge on a level with the end of the branch. Two scions are inserted in each cleft, one at each end of the cleft. After these have been properly placed the wedge used to hold the halves of the branch apart is removed and the waxing done. Either grafting-wax or melted parawax is applied in such a way that all the exposed inner tissues are completely covered as shown at E. The waxing must be done carefully to prevent displacement of the scions.

The Bark-graft.—In bark-grafting the branch is prepared in the same way as for cleft-grafting excepting that no cleft

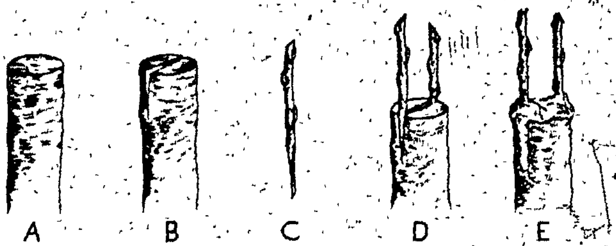

FIG. 8.—CLEFT-GRAFTING

is made. In place of the cleft two slits in the bark on opposite sides of the branch and parallel with the branch are made. These should be about one and one-half inches in length and should be made through the bark. A branch prepared and with one slit showing may be seen at A in Fig. 9. The scion is prepared as shown at B. A square cut is made half-way through the scion at a point about one and one-half inches from its base. This cut should be made just below a good bud located on the opposite side of the scion. From this point to the end, the scion is made wedge-shape, tapering on the inner side only, however. One edge of the wedge is then pared slightly to expose the cambium and to make a straight edge that will fit closely against the edge of the unloosened bark on one side of the slit in the stock. The tip of the wedge of the scion should be sharpened on the outside to expose more cambium and to permit this to come in contact with the cambium of the stock at another point. The scion is then

ready for insertion. The bark on one side of the slit made in ~~the stock is loosened with the point of the knife and then the~~ scion is inserted. The scion is pushed down under the loosened bark of the stock until the square shoulder of the scion rests on the cut end of the branch. The straight edge of the wedge must fit closely against the edge of the bark on the opposite side of the cut and which was not loosened. Two small nails are then driven into the bark, through the scion, and into the branch as shown at C. Two scions, one at each side of the branch, are inserted. The end of the branch and the bases of the scions are then coated with liquid wax applied with a brush as shown at D. It is a good plan to coat the upper end of the scion also with wax to prevent undue drying of that part.

A form of bark-grafting preferred by some is that where the bark on both sides of the slit in the stock is loosened. The

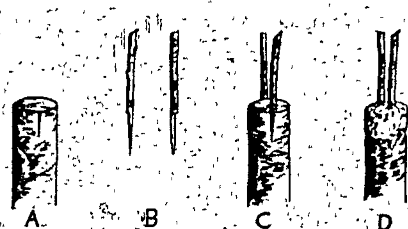

FIG. 9.—BARK-GRAFTING

scion is prepared in the same way as that in the other form described excepting that one edge of the bevelled surface is not pared. The scion is inserted medially and nails are driven into the two portions of loosened bark, through the scion and into the branch.

While two scions are inserted on each branch in cleft- and bark-grafting, only one is required for the new branch and usually only one is allowed to remain. Two are used to insure success in the operation of working the tree over to the desired kind. Where both scions unite with the stock the poorer one is removed and this is done before much growth has taken place.

The scions thus applied unite firmly with the tree. They develop into branches which become integral parts of the plant. These branches flower, bear fruit and perform the other functions performed by normal branches.

The Side-graft.—The side-graft is easily made and can be used to advantage on the smaller branches. Branches up to

three-fourths of an inch in diameter may be worked in this way. At a suitable place on the branch a cut is made at an angle in the direction of the base of the branch and toward the centre of the branch. This should be about one inch in length. A scion is then cut to wedge as in cleft-grafting. The prepared scion is then inserted in the cut and this is facilitated by bending the branch slightly to open the cut. The thicker side of the wedge of the scion is placed toward one side of the cut and the cambium layers are brought in contact. Tying is un-

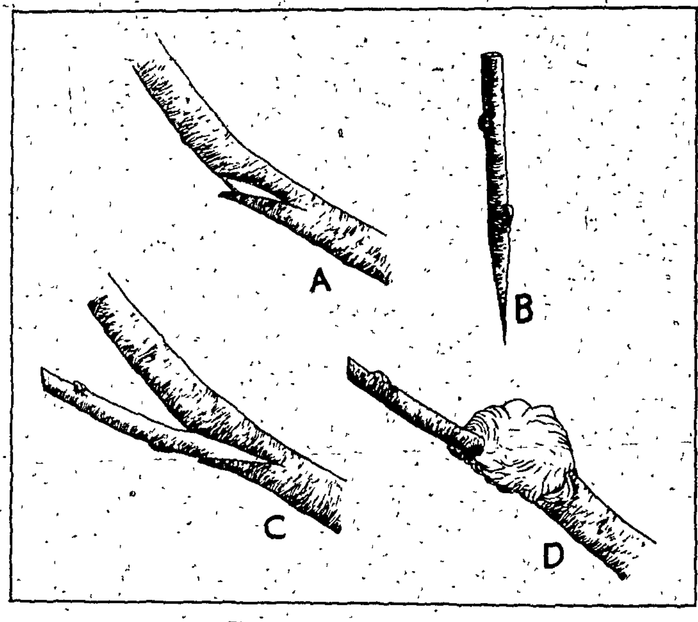

FIG. 10.—SIDE-GRAFTING

necessary as the spring of the branch is sufficient to hold the scion in place. Either fluid or soft wax is used to cover the cut and the base of the scion. The branch is then removed just above the cut and the wound thus made is covered with wax. The various steps in the operation are shown in Fig. 10.

Bridge-grafting.—Bridge-grafting is used in repairing trunks of trees that have been girdled or partially girdled by mice and rabbits and that have been injured by some other agency. It is a form of tree surgery. Various forms of this type of grafting are used but these are identical in principle and similar in detail. Dormant scions of the same kind as the plant to be repaired must be used and the operation is performed

in the spring just after growth begins. In the case of fruit trees bridge-grafting can be performed successfully up until the flowering season provided the scions can be kept dormant until that time.

The first step in the operation of bridge-grafting is that of trimming the bark on the trunk of the tree to be repaired. A girdled stem is shown at A in Fig. 11. The damaged bark should be cut back to sound bark and the ends should be made square as shown at B. In some cases it is necessary to place one end of the scion into the part just below the ground surface and in this case the soil should be drawn back and the part concerned prepared as the part above ground. The exposed wood should be cleaned and given a coat of standard liquid grafting-wax or of heated ordinary

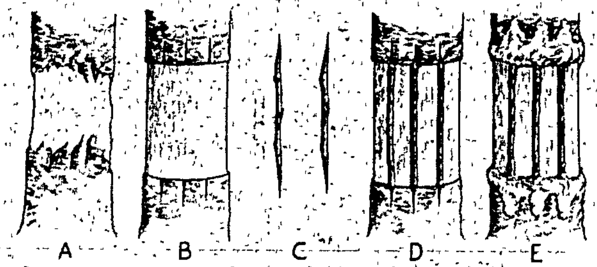

FIG. 11.—BRIDGE-GRAFTING

grafting-wax. The scions are then prepared as shown in C and they must be cut sufficiently long to permit the formation of a slight outward bow when in position. The ends are made wedge-shape with a diagonal cut of one and one-half to two inches in length on one side and about one-third of this on the opposite side. The two ends of the scion are prepared in the same way. Vertical incisions about one and one-half inches long are then made through the bark of the trunk, one above the exposed wood and one below it for each scion. The bark on each side of the slit is loosened with a knife and then the scion is inserted. The side of the scion with the long wedge is placed inward and toward the wood and the side with the short wedge is placed outward and toward the bark. A small nail is then driven into the bark on the trunk near the slit, through the top of the scion and into the wood. This is done on each side of the slit and at each end of every scion used.

The scions should be placed as close together as conditions will permit and it is usually practicable to place them from one and one-half inches to two inches apart. In some cases they can be placed closer than this. It is advisable to drive a small nail through the bark on the trunk of the tree and into the wood between the points where each two scions are to be inserted. This prevents the loosening of the bark all the way around the trunk when preparations for the insertion of the scions are being made. Scions in place and the bark nailed are shown at D. Immediately after the scions have been placed a coating of either fluid grafting-wax or melted parawax is applied to all joints and exposed inner tissues. This can be applied to advantage to the scion also. The operation completed is shown at E.

In many cases shoots develop on the scions used in bridge-grafting. These are of value in that they result in a more rapid diameter growth of the scion and should be left until the beginning of the second season at least. It is usually advisable to remove the shoots at this time but where the scions appear not to be well established this removal may be delayed one year.

Success in Budding and Grafting.—Budding and grafting are made possible through the ability of young cells in one plant part to unite with similar cells in another plant part. When brought into proper relationship these groups of cells grow together making a firm union between the parts concerned. Such cells make up the cambium layer of the plant. This tissue lies between the bark and the wood and is only a few cells in thickness. Being very delicate it is easily injured and is very sensitive to drying. When cut with a dull knife and when exposed unduly to the drying influence of the atmosphere these tissues fail to unite.

Success in budding and grafting depends primarily on the ability of the operator to bring together the cambium of the bud or scion and the cambium of the stock in such a way that union will take place. One operator is able to induce 90 per cent of his buds or more to take while another may consider himself fortunate in obtaining a 25 per cent take. One has mastered the art while the other has failed in the attempt to do so. Graftage is not shrouded by mystery and can be learned by any intelligent person in a very short time. Certain laws must be recognized, however. The form of graftage may vary greatly but the methods used must be based on sound principles. A knowledge of the principles of graftage, a knowledge of the nature of the parts being used and a full

realization of the necessity of carefulness, thoroughness, speed and accuracy in the operation are requisite if success in good measure is to be attained.

Layering

Layering is the propagation of plants by means of layers. A layer may be defined as a shoot or branch attached to a plant and which is partially or wholly covered with earth or some other rooting medium with the intention that it will root and then be severed from the parent plant. After being separated from the parent plant the rooted shoot or rooted branch is treated as a separate plant.

This method of propagation requires more care in dry regions than in regions where there is at least a moderate amount of rainfall. Moisture is very essential and the rooting medium must be kept moist throughout the season. The use of water may be necessary at times in the prairie provinces of Canada. Where possible a mulch should be employed and this may, in some cases, obviate the necessity of using some of the water required under ordinary conditions.

While various forms of layerage are practised only three of these are important in the propagation of plants of hardy fruits. They are usually designated as (1) common, (2) tip and (3) mound.

Common Layering.—In common layering the branches are brought in contact with the ground and are covered over part of their length with moist soil. The end of the branch is left exposed. The use of a peg driven into the ground is often necessary to hold the branch in place. The depth of soil required is four to six inches and this must be kept moist at all times. A diagonal cut into the lower side of the portion of the branch covered frequently stimulates root development and it is good practice to make such a cut in all branches to be layered in this way. This type of layering is illustrated in Fig. 12.

In the case of the common layer the branches are usually covered in the spring before growth begins. Branches of many plants treated in this way will root the first year but in some cases two years are required. After becoming well rooted, the layers are severed from the parent plant and treated as separate plants. The cut is made just above the earth used to cover the branch and below the section of the stem bearing the roots. This is done early the following spring and the new plants are reset at once.

The currant and gooseberry may be propagated by common layering. This is not the usual method employed for these fruits but it is a very certain method and where only a small increase is desired it may be used to advantage. The stems of plants of most varieties will root in one season and the layers may be severed from the plants the spring following and treated as separate plants at that time.

Tip-layering.—In tip-layering merely the tip of the cane is buried. Sufficient earth is used to cover the tip well and

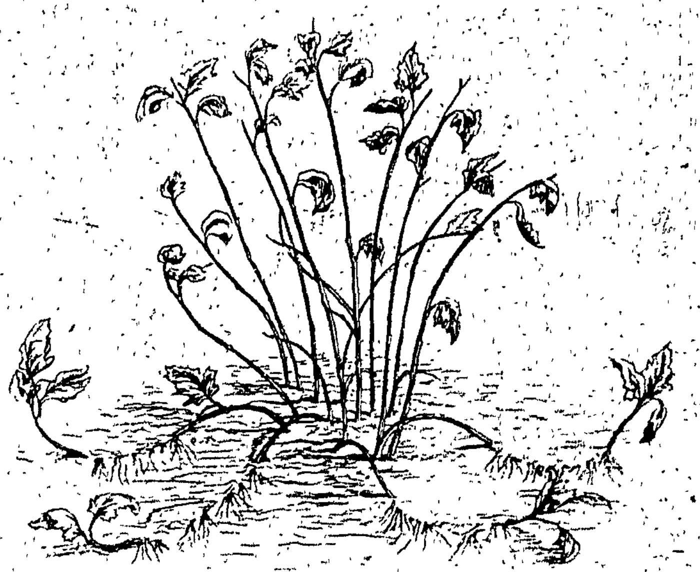

FIG. 12.—COMMON LAYERING

to hold the cane in the position required. The soil covering must be kept moist. This type of layering is usually performed late in the summer and by late autumn roots will have formed on the part covered. From one of the buds formed a shoot will develop the following season. The rooted tip is left undisturbed until spring at which time it is severed from the plant, taken up and replanted. About six inches of the old branch is taken with the rooted tip to serve as a handle. In Fig. 13 a layered cane and a young plant resulting are shown.

The black raspberry, purple-cane raspberry, loganberry and dewberry are usually propagated in this way. The tips of the canes are put down about the time growth for the

season is completed. The rooted tips are transplanted the following spring and are usually grown in the nursery row for one year. During the next spring they are transplanted to the permanent location.

Mound-layering.—Mound-layering is the common method of propagating the gooseberry. Well-established plants that are to be used for the purpose are cut back severely early in the spring. The usual plan is to cut them back to within four inches of the ground level. This results in the production of

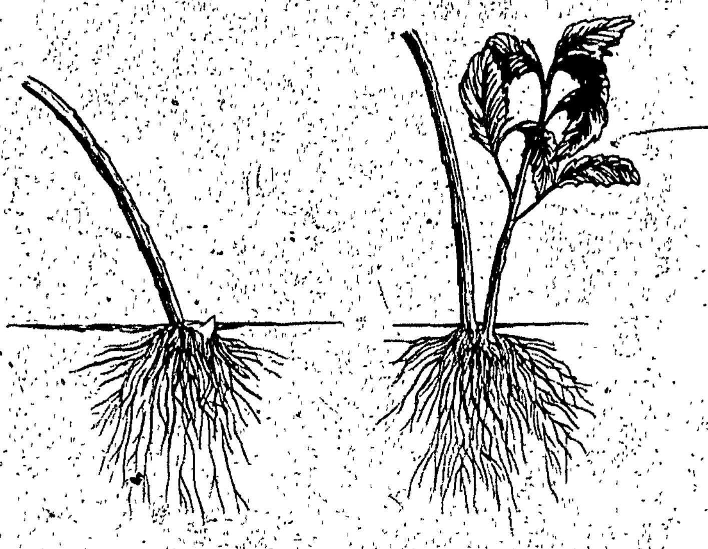

FIG. 13.—TIP-LAYERING

many shoots. When the new shoots are from four to six inches high moist soil is banked around the plant leaving the tips of the shoots exposed. As the shoots grow, more soil is drawn around the plants until eight inches at least covers the base of the plant. This soil must be kept moist at all times. Rooting takes place and by autumn most of the shoots will have rooted. This method is illustrated in Fig. 14. The following spring the bank of soil is pulled back carefully, the rooted shoots removed and each rooted shoot treated as an individual plant. These rooted shoots are usually grown in the nursery-row for one year at least before being planted in their permanent locations. The old plants are left undisturbed after the rooted shoots are removed and each year

they will produce a crop of new shoots for the making of additional layers.

Layering Tree Fruits.—Layering has been employed in a small way in the propagation of tree fruits but it has not been found sufficiently practicable to permit suggesting its use in this case at the present time. When more is known about the reaction of plants of tree fruits to different environments the successful propagation of this class of plants by layering may become general.

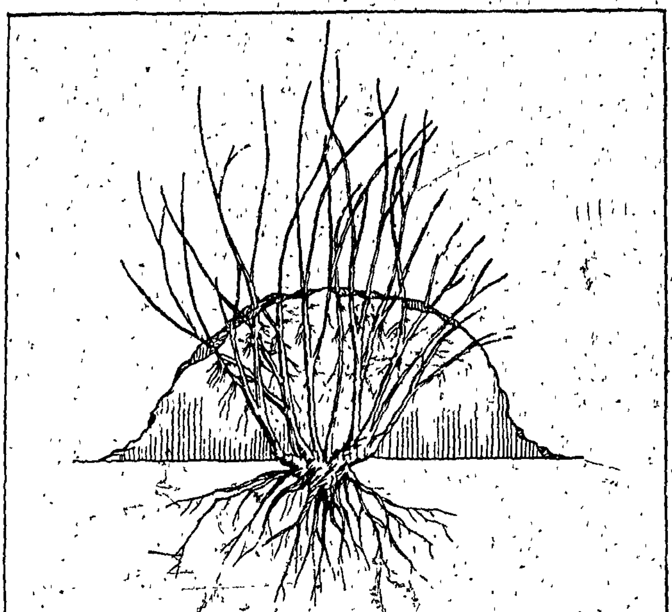

FIG. 14.—MOUND-LAYERING

Natural Layering.—Though usually considered an artificial method of propagating plants, layering is at times a natural method of making increase. In certain plants branches come in contact with moist soil naturally and develop roots. This is not uncommon in the black raspberry, currants and gooseberry. The plants resulting are frequently quite as satisfactory as those from artificial layering.

CUTTINGS

The use of cuttings is one of the simplest methods employed in the propagation of named varieties of fruits. The

cuttings are easily made and if given proper conditions they will root readily and develop into good plants in a short time. Only certain kinds of plants, however, can be propagated by this method. The cuttings used in the making of increase in hardy fruits are made either from the stem or from the root.

Stem-cuttings.—Stem-cuttings used in the propagation of fruits are usually made from mature and dormant wood. The best material for use is vigorous shoots produced the summer just passed. Older wood may be used but it is found that cuttings from younger shoots root more readily than those from older shoots. The cuttings may be made any time during the autumn after the shoots mature, but it is advisable to make them as early as the condition of the wood will permit. It is usually possible to make them early in October in the prairie provinces. Most stem-cuttings are made from five to ten inches in length, and it is good practice to make the base of the cutting just below a node or joint. In some cases, location of the base of the cutting is not important but in others it is and it is advisable in the cases of fruits to make the basal cut at the point mentioned. Cuttings need not be terminal and several may be made from one long shoot. The shoots for making the cuttings should be taken from the plants just before the cuttings are to be made and the material should not be allowed to dry. Immediately after being made the cuttings are tied in bundles of twenty-five to fifty and placed in winter quarters.

While indoor storages may be used for the storage of cuttings during the late autumn and winter, the safest and most practicable place is in the ground outdoors. A shallow trench sufficiently wide to accommodate the cuttings when placed crosswise is made and the bundles are placed crosswise in the bottom of this trench. Moist soil is used as a covering and when the cuttings are made early in October a soil covering to the depth of four to five inches is ample. When the cuttings are made toward the end of October or just before winter sets in a deeper trench should be made and the cuttings given a covering of eight to ten inches or more. Buried in this way the cuttings are left undisturbed until early the following spring when they are taken up and planted.

Stem-cuttings taken at planting time in the spring and planted at once are much less successful than those taken in the fall. A small percentage thus handled may root, however. The taking of the cuttings two or three weeks in advance of planting and burying them shallowly in the ground until planting time is preferable to taking them later and planting

at once. Where the matter of taking the cuttings in the fall was overlooked spring-made cuttings should be used but such a procedure should be adopted in cases of emergency only.

To root well, cuttings of dormant wood must be made some time before growth is expected to begin and must be stored under conditions that will permit healing of the wounds to take place. A moist covering and a temperature above the freezing point, but sufficiently low to prevent opening of the buds, are indispensable. Exposure to these conditions for two or three months is ample and in some cases even a shorter exposure will suffice. Where made early in October, cuttings are exposed to the conditions required for a month or more in the autumn and for a short period at least in the spring after the soil thaws and before the planting is done.

External evidences of healing of wounds may or may not be present at planting time. In many cases a mass of tissue light in colour and with a pitted surface forms on the lower ends of the cuttings. This tissue is referred to as callus. Its formation in many cases is a preliminary to rooting. Where callus does not form, the stem is sealed a short distance below the cut surface. The upper end of the cutting also is sealed just below the tip. Even though not in evidence the latter form of healing appears to be quite as effective as the former in many cases at least and cuttings that are without callus after treatment usually root as readily as those showing callus development.

The Planting of Stem-cuttings.—The proper planting of cuttings is very important. Cuttings should be set at an angle of thirty degrees to the ground surface, approximately, and at such depth that the uppermost bud can barely be seen above the soil. If the topmost bud is of doubtful character the cutting should be set a little higher so that the second bud is at the ground surface. The soil should be in close contact with the cutting and this may be insured by making the opening required with a narrow spade. This spade is driven into the rooting medium at the desired angle and to the depth required for the cutting being planted. The handle of the spade is then lifted or pushed forward a short distance and the cutting inserted. The spade is then withdrawn and the earth allowed to fall upon the cutting. A foot is then applied with considerable pressure to the soil above the cutting after which the slight depression resulting is filled with loose earth. This brings the soil in close contact with the cutting and improves conditions for rooting. The cutting must be placed with its basal end down. The basal end is usually the larger and is the

one that was nearer the base of the shoot from which the cutting was made. The buds point away from the base of the cutting and their angular or rounded tips are toward its apex.

The best rooting medium for cuttings is one that contains considerable moisture and permits a free movement of air. Since hardwood stem cuttings are usually planted in rows in the open, soil is the usual rooting medium employed. Porous soils are preferable to close soils and a sandy soil is found more satisfactory than one that is heavy in nature. Where special beds for the rooting of cuttings are made up considerable sharp sand should be used and a medium consisting of one-half sand and one-half garden loam should give good results. Ordinary garden loam in a well-drained area will give fair results and the cuttings may be planted in this when a more porous rooting medium is not available. Moisture is indispensable and the rooting medium, whatever it may be, must be kept moist throughout the season.

Stem-cuttings are used extensively in the propagation of the currants and the grape. Certain varieties of the gooseberry lend themselves to propagation by this means and such varieties are sometimes increased in this way. Details are given for the propagation of these plants by this method under their respective headings.

Root-cuttings.—Root-cuttings are used in few cases in the propagation of fruit plants. When propagating stock is scarce the red raspberry and blackberry are increased in this way. The tree fruits may be propagated by this method but since the underground parts in these cases are stocks and not of named varieties any increase made by root-cuttings is increase of stocks only. In certain cases, however, plants of named varieties of tree fruits that are on their own roots may be propagated in this way. This method has a value in the production of uniform stocks for tree fruits where such stocks are demanded.

The material for root-cuttings is usually from one-fourth inch to one-half inch in diameter and the cuttings are made from one to three inches in length. Smaller roots may be used but these are not as satisfactory as the larger. For indoor planting the shorter lengths are suitable but for outdoor planting the greater lengths are desirable.

For good results root-cuttings should be made some time in advance of planting and stored at a temperature a few degrees above freezing. This is to permit the healing of the wounds and the development of shoot primordia that are ordinarily absent in the roots. The safest and most

practicable plan is that of taking them in the fall and burying them in the ground to a depth of a few inches as for stem-cuttings. These are left undisturbed until spring, at which time they are taken up and planted. In tree fruits the plants from which the root-cuttings are to be taken may be dug up carefully and replanted after the roots suitable for cuttings have been removed. When the cuttings are made in the autumn the plants to be reset should be heeled-in in a sheltered place and replanted in the spring. Where making the cuttings in the fall is not practicable the plants may be dug up as early in the spring as possible, the root-cuttings made and buried shallowly in the ground at once and the plants replanted without delay.

The best rooting medium for root-cuttings is similar to that for stem-cuttings. A porous sandy soil usually gives excellent results and this is to be recommended for rooting this class of cutting.

Root-cuttings may be started either indoors or outdoors. Where facilities are available the cuttings may be started indoors early and the rooted cuttings transplanted to the open soon after the shoots appear. Cuttings handled in this way will result in larger plants by the end of the first year than will cuttings planted directly out of doors. Plants from cuttings set directly in the open are very satisfactory, however.

Runners

Runners or stolons are creeping prostrate stems that are capable of producing at a joint or node a shoot above and roots below. The shoot produced above is frequently very short and often takes the form of a crown bearing a rosette of leaves. To develop roots the joint must have the stimulus of moisture and contact with moist soil is sufficient to induce rapid root development. A joint with its roots and shoot thus becomes a plant and the stem connecting this new plant with the parent plant eventually ceases to function and dies. In some cases the runner becomes several jointed before any rooting takes place while in other cases the first joint to produce a plant may become an established plant before the second joint appears. A plant may produce several runners and a number of new plants may thus be produced directly from one plant. Each new plant will develop runners in due time and these in turn will produce new plants. Increase by this method is usually rapid and a large number of plants may result from one plant in a single season.

The strawberry is propagated by runners. Runners are usually produced freely in this fruit and when conditions for rooting are favourable many new plants result. The strongest and best of these plants are taken up and used in starting a

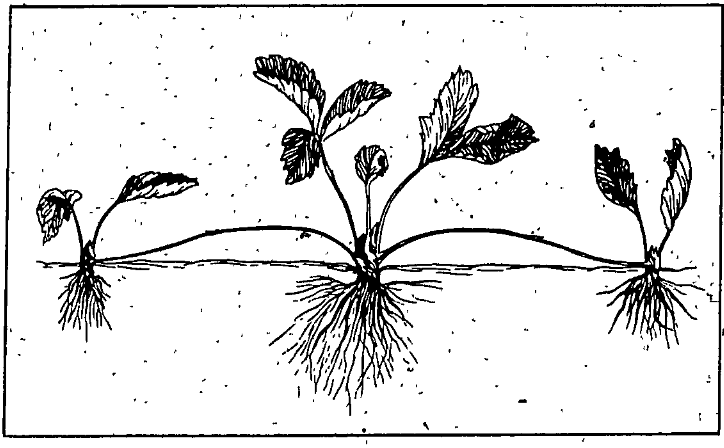

FIG. 15.—STRAWBERRY RUNNER

new plantation. Runner development in the strawberry is illustrated in Fig. 15.

SUCKERS

Suckers are shoots that are sent up from the roots or other underground parts of certain plants. These suckers behave as independent plants and in many cases they develop well-defined root systems in the early stages of development. In other cases suckers are slow in developing independent root systems and for some time depend on the roots of the parent plant for the necessary supplies of moisture and mineral salts.

The term "suckers" is sometimes applied to long slender shoots that arise on the trunk and near the bases of large branches of certain trees. They are correctly termed "water sprouts" and should not be confused with true suckers.

Since they have their origin in the underground parts, suckers are not always of the same variety as the fruiting part of the plant. In budded and grafted plants, for instance, the underground part is usually all stock and suckers produced in such cases are of the stock and not of the named variety. In plants propagated by cuttings, suckers and

divisions, on the other hand, the underground part is identical with the part above ground and in such cases any suckers produced will perpetuate the variety.

Suckers are used in the propagation of certain fruit plants. The red raspberry and blackberry are usually propagated in this way. These plants produce suckers freely and the suckers develop independent root systems in the early stages of growth. These suckers are dug up and replanted in the area

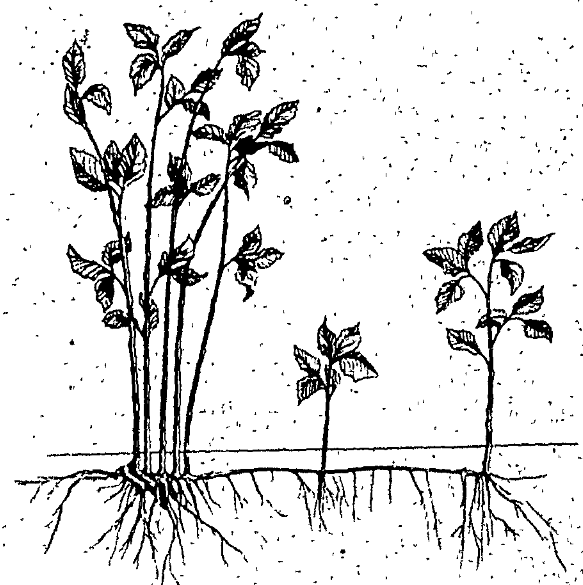

Fig. 16.—Parent Plant and Suckers in Red Raspberry

to be occupied by the new plantation. In Fig. 16 suckers are shown developing a short distance from the parent plant in the red raspberry.

Divisions

While less important in the propagation of fruits than most of the other methods discussed, division is used to some extent in the multiplication of certain fruit plants. As the term implies, division is the cutting or the breaking apart of a plant for the purpose of making increase. In some cases the entire plant is merely cut or broken into sections, allowing a portion of the underground part to remain with each portion

of the part above ground made. A plant with a large crown and with numerous shoots arising below the ground surface, as is frequently found in the common lilac, lends itself admirably to multiplication by this means. In other cases only the over-wintering underground part is concerned and this is divided in such a way that each section made has at least one fleshy root and a portion of the crown bearing at least one bud. In the rhubarb, the clump, which consists of large fleshy roots and a crown, is divided and to each section made goes part of the crown and part of the fleshy root system.

Division is used to a small extent in the propagation of the raspberries, blackberry, currants and gooseberry. Plants of the raspberries and blackberry are adapted to this method of propagation but the standard methods employed for them are usually much more satisfactory. The clumps are merely divided, each division having at least two or three canes and a section each of the crown and of the roots. Plants of the currants and gooseberry are less adapted to being increased in this way because of the type of plant they represent. Some plants of these fruits, however, have the necessary structure for increase by this means and can be divided successfully.

Grafting-wax

Many formulae are used in the making of grafting-wax. Some of these are better for certain purposes than others. Each recognized formula was designed to give a grafting-wax especially suited to certain needs and in most cases these waxes meet the requirements of the purpose for which they were intended.

Moderately hard Wax.—A formula that is used extensively in the making of grafting-wax and one that results in a moderately hard product is as follows:

Crushed resin	4 pounds
Beeswax	2 pounds
Beef tallow	1 pound

These three ingredients are melted together in a pot over a fire and the liquid is stirred well to obtain a uniform mixture. The melted mixture is then poured gradually into cold water. The hands are then greased and the wax pulled, as the sugar mixture in the making of taffy, until a uniform texture results. This wax may be heated and applied with a

brush. It should be heated only to the point where application can be made easily, however.

Soft Wax.—A softer wax and one that can be more readily used without heating is made as follows:

Crushed resin . . .	5 pounds
Beeswax . . .	1 pound
Boiled linseed oil . .	$1\frac{1}{4}$ pounds

The resin and beeswax are melted together. The linseed oil is then stirred in. After cooling, the wax is ready for use. If a very soft wax is desired more oil should be added.

Fluid Wax.—It is frequently difficult to make a good job waxing a graft using ordinary grafting-wax without displacing the scion. Liquid grafting-waxes offer distinct advantages over ordinary grafting-waxes in that they are applied with a ~~brush and tend to flow into crevices difficult to reach with~~ harder waxes. A good formula for liquid grafting-wax is as follows:

Resin	1 pound
Beeswax . . .	1 ounce
Alcohol	5 ounces
Turpentine . .	1 ounce

The resin and beeswax are melted together over a fire. After the melting is completed the mixture is removed from the fire and the turpentine and alcohol are added gradually as cooling takes place. Alcohol vaporizes readily and if added to the very hot mixture it will be lost. This wax must be kept in a tight container when not in use. Either grain (ethyl) or wood (methyl) alcohol may be used but the concentration must be high. By lessening the amount of alcohol and turpentine one obtains a thicker fluid and this is desirable in some cases at least.

Paraffin.—Melted paraffin makes an excellent wax for use in budding and grafting. Parawax, a form of paraffin used to seal jars of jelly and jam, is very satisfactory for this purpose. This form has a fairly low melting-point and if kept at a temperature of 140° F. or 150° F. it can be applied readily and will not injure the tissues.

Waxed String

To resist decay, string used in tying grafts to be stored must be given a special treatment. Knitting cotton of the No. 18 or No. 20 size is usually employed and balls of this are plunged into hot resin and kept there for a few minutes. The

ball should be turned several times to permit uniform penetration of the resin. A small nail, or some other such object, should be tied to the end of the cord to be drawn before the treatment is given to assist in the location of this end when the string is to be used.

CHAPTER III

NURSERY STOCK AND ITS GENERAL TREATMENT

Selection of Varieties.—In selecting fruits for his plantation the grower should give special attention to the matter of variety. Too often does he overlook the importance of variety and accept without question plants of any variety that the nurseryman has to offer. Reliable nurserymen seldom accept orders for plants that would have little chance of proving satisfactory to the customer, but in many cases nurserymen are not sufficiently familiar with conditions in a particular region to enable them to distinguish between varieties that will be successful and varieties that will result in failure. Frequently, a nurseryman has a surplus of plants either of varieties for which there is little demand or of varieties that are easily propagated and the low prices quoted on these often tempt the grower to place an order for stock regardless of its suitability for the conditions concerned. Only those varieties that either have given or are likely to give satisfaction in the region in which the plants are to be grown should be selected and the recommendations made by local growers and by workers at universities and experimental stations should be followed religiously.

The Basis of Selection.—The important qualities for which varieties should be selected in the Great Plains region are hardiness, quality of fruit and productiveness. Varieties differ greatly with respect to these qualities. In plums, for instance, are found varieties, the plants of which will not survive one winter in Western Canada and in the same fruit are varieties the plants of which are quite hardy in this section. Among the hardy varieties are those producing fruit of good quality and also those producing fruit of poor quality. Some varieties are found to be very prolific while others tend to be shy bearers. This is true in crab-apples and cherries and probably to a lesser extent in the other hardy fruits grown. Quality and productiveness are very important in all fruits and only the best and most productive varieties possessing the hardiness demanded should be considered when the list for the plantation is being prepared.

Variety necessary for Fruitfulness.—The importance of having sufficient variety to insure fruitfulness should not be

overlooked. Many varieties of tree fruits are self-sterile and if trees of such varieties are planted alone either no fruit or very little malformed fruit will be obtained. In our common tree fruits fertilization of the flower must take place if fruit is to be borne. The pollen produced by the male organs of the flower, or the stamens, is transferred to the female organs, or the pistils, and results in the fertilization of the part of the flower that gives rise to the fruit. In self-sterile varieties the flowers of a given variety either are not fertilized by pollen of the same variety or fail to produce either viable pollen or normal ovaries. The latter is not common in our tree fruits and most cases of self-sterility in these fruits are due to the unsuitability of the pollen of the same variety. If the plants of a self-sterile variety are to be fruitful their flowers must receive pollen from the plant of another variety of the same kind of fruit. If, for instance, ten trees or more of the crab-apple variety, Osman, were planted and if trees of another variety either of the crab-apple or of the standard apple were not in the vicinity no fruit could be expected. A thousand trees of one variety would be the same as one tree in this respect because all the trees of Osman crab-apple in existence are the same. They are the same because propagation is effected by vegetative means—by taking a small portion of the plant, such as a bud or a section of a twig, and producing from this a new plant or the part of a new plant that gives rise to the fruit. Because of this, all trees of a named variety of apple are identical and when a variety is self-sterile any number of trees of that variety planted alone will be unfruitful. This is true in plums and cherries too. When trees of another variety of the same fruit are near by, when the varieties are compatible, when flowering in the two varieties takes place at the same time, and when agents for the transfer of pollen, such as honey-bees, are present, fruiting will result.

While it is an established fact that certain varieties of tree fruits are self-fertile and are able to fruit when planted alone it is advisable to regard all varieties of these fruits as self-sterile. Varieties that are considered self-fertile sometimes become self-sterile. Even the self-fertile varieties usually fruit better and produce larger fruit when plants of other varieties are present than when they are planted alone. At least two varieties of each of these fruits that are to be grown should be represented in the fruit plantation. Because of the possibility of the trees of one variety failing to bloom in a given year or because of the times of blooming not being similar or

because of the two varieties selected being incompatible it is advisable to use plants of three or four varieties or more of each fruit to be grown.

Mention should be made of the fact that one kind of fruit will not serve as a pollenizer for another kind. Apple pollen will not result in the fertilization of plum flowers and plum pollen will not result in the fertilization of apple flowers. In some cases plum pollen will result in the fertilization of flowers of certain cherries and pollen of certain cherries will result in the fertilization of certain plums but this is exceptional and such combinations should not be depended upon to give crops of fruit.

In the bush fruits and in the strawberries self-fertilization appears to be the rule but even in these the growing of a second variety is usually advantageous. Under certain conditions varieties of these fruits appear to become partially self-sterile and the use of a second variety may increase fruitfulness in such cases.

Selection of Stock.—The selection of good stock is quite as important as the selection of suitable varieties. Inferior stock is costly at any price and it is responsible for much of the difficulty experienced in establishing fruit plantations. Good stock, on the other hand, will go a long way in making the undertaking a success.

All plants to be used should be young, clean, vigorous, free from injury and with good root systems. In addition, budded and grafted plants should be on suitable stocks.

It is much safer to buy woody plants that are graded according to age than those graded according to height. Such plants frequently differ greatly with respect to rate of growth and a plant of a given variety that is four to five feet high may be only one year from the bud, while another of the same variety that is only two or three feet in height may be two years old or more. The latter would be lacking in vigour and might be classed as a "runt". In all probability this "runt" would never make a satisfactory tree. The younger and larger tree in this particular case would be a much better investment than the older and smaller tree and would doubtless prove more vigorous and more productive.

One-year-old stock is preferable to that older, in the majority of fruits at least. When furnishing one-year-old plants the nurseryman is obliged for the sake of appearance to deliver plants that have made at least a reasonable amount of growth and any plants supplied could be depended upon to have the desired vigour and to give satisfaction. One-year-old

plants are less costly than those older and in some cases considerable saving can be effected by purchasing the younger stock. Young plants are usually smaller and more easily handled and planted than older plants and the mortality resulting from the transplanting is frequently much lower in the former than in the latter. Established plants may be had, therefore, at considerably less cost when one-year-old plants are purchased than when older plants are employed.

FIG. 17.—PLUMS AND CRAB-APPLES IN A CITY BACKYARD

Well-chosen varieties give satisfaction. This shows a Pembina plum and a Pioneer crab-apple in bloom.

The use of plants free from disease and insect pests is very important. It is important at all times and it is especially important now to obtain plants with a clean bill of health because of the absence of certain diseases and certain pests in parts of the West. Unless care is exercised by nurserymen and by growers, some of the enemies of fruit plants that are confined to certain quarters at present will probably become widely distributed in the near future and will make the successful culture of fruit in prairie sections more difficult than it has been or is now. Needless to say, plant enemies frequently result in great losses and any step that will reduce

this hazard and that is practicable is worth while. Making certain that the stock to be planted is clean and will not prove a menace to other plants in the plantation and in the district is a precaution that should be taken by every planter.

A good root system is essential if the plant is to do well after being replanted. Plants with few large roots devoid of laterals are likely to have a struggle in becoming re-established while those with numerous small roots should become re-established quickly and should not suffer a severe set-back as a result of having been moved. A great root-spread is not necessary but the roots present should be sufficiently long to give ample surface for a normal functioning of the underground parts.

The need of appropriate stocks in the cases of budded and grafted plants cannot be emphasized too strongly. To be of value where the winter temperatures are very low, stocks must be extremely hardy and the use of tender stocks for such conditions results in the failure of the plants to survive regardless of the hardiness of the variety propagated. Very hardy stocks are therefore a prime requisite in the Great Plains region. The stocks and the varieties propagated on those stocks must be congenial if the plants are to be thrifty and productive and this is a matter that the nurseryman should not overlook. Fortunately, stocks that are extremely hardy and that are congenial are available for the hardy fruits that are propagated by budding and grafting and only such stocks are used by dependable nurserymen.

Sources of Plants.—Fruit plants are usually obtainable only from the professional nurseryman and from the grower that has a surplus of stock. Both sources should be satisfactory but at times a nurseryman or a grower supplies stock that fails to measure up to the expectations of the customer. It is a good policy for the purchaser to investigate the integrity and reliability of the individual or company from whom it is proposed to obtain the plants before placing the order and thus reduce the possibilities of disappointment. Near-by sources are usually preferable to distant sources, other conditions being equal, and the intending purchaser is advised to obtain his plants as near home as possible when conditions warrant doing so.

It must not be inferred that plants from distant points will not give satisfaction. Plants of a given variety propagated in one part of the country will be as satisfactory as plants of the same variety propagated in another part, provided suitable stocks have been used in both cases. Plants of Assini-

boine plum, for instance, propagated in Ontario or British Columbia will do as well in the prairie provinces as plants of the same variety propagated in the coldest sections in which the variety is hardy, provided suitable stocks have been used. The matter of transportation is a factor and the shorter the time the plants are in transit the better. It is always good policy to support home industry where possible and a distant source should be used only where conditions demand it.

When to obtain Plants.—The best time to obtain all fruit plants, with the single exception of those of the strawberry, is late in the fall. Orders should be placed early in the autumn and request made that delivery of the plants take place a short time before winter is likely to set in. Few orders are placed and filled by most nurserymen in the autumn and disappointment resulting from the inability of the nurseryman to supply the stock ordered is usually avoided when this plan is followed. Plants delivered in the fall are more likely to arrive in good condition than those delivered in the spring because the nurseryman is less rushed in the autumn and can exercise more care in the packing and handling of the stock. Climatic conditions are usually more favourable for plants in transit in the fall than in the spring and this is no small factor contributing to the success of fall shipments. Further, autumn delivery results in the stock being on hand for planting early the following spring. While most nurserymen make a special effort to make their spring deliveries reasonably early it is impossible for them to fill all orders in time to ensure early arrival of the plants.

Where the matter of ordering the plants in the fall has been overlooked or where spring delivery is preferred for some special reason the order should be placed during the early part of the winter. Orders are usually filled in the sequence in which they are received and customers ordering early are less likely to be disappointed than those ordering late. Request should be made that delivery take place as early in the spring as possible. The prospective customer should bear in mind that the nurseryman may not be able to fill completely an order placed at this season and should specify that substitution of varieties will not be permitted unless the varieties offered as substitutes are acceptable to all parties concerned.

Plants of the strawberry may be ordered any time during the winter or early in the spring. Delivery should be made at planting time and the most favourable time for setting plants of this fruit is usually during the second or third week in May.

Treatment of Plants upon Arrival.—As soon as possible after their arrival from the nurseryman, plants should be unpacked and their roots plunged in water. Where the nursery stock has been shipped a short distance only, and where careful packing has been practised, it is unnecessary in most cases to leave the roots immersed more than an hour or two, but where the roots are dry and where the plants appear to have suffered from lack of moisture in transit, the immersion treatment should be continued for at least twenty-four hours. If the bark of the stems of woody plants has shrivelled, as sometimes happens when the stock has been poorly packed, the stems too should be submerged in and kept under water for a twenty-four-hour period. In extreme cases these periods could be extended with advantage to forty-eight hours but this should be considered the maximum.

Where delivery in the autumn has taken place the plants should be either heeled-in or buried in soil out of doors immediately after being taken from the water. A trench nine to twelve inches deep and two feet in width, with one side making a vertical line and the other a long slope, is dug and the plants are placed crosswise in this trench. The roots are placed on the deep side of the trench and the stems rest on the sloping side. The plants should be placed singly in this trench and so spread that the soil will come in contact with their roots readily. The trench is then filled with moist soil and this soil is firmed. If it is practicable to do so, water should be applied freely after the roots have been covered and before the trench has been filled. Water applied in this way settles the soil and brings it in close contact with the roots. In this case the trench is filled immediately after the water soaks away. Merely filling the trench results in a covering for the roots and the lower parts of the stems and this may be sufficient in most cases. Banking the soil over the plants and covering the upper parts completely to a depth of three or four inches is desirable, however, but this should be delayed until winter is setting in.

In the case of spring delivery of the stock the planting should be done immediately after the plants have been removed from the vessel containing water. If, however, this is not possible or if it is not convenient to do so immediately, the plants should be heeled-in well in moist soil to await being planted. The roots and at least two-thirds of the parts above ground, in the case of woody plants, are covered with moist soil. Sufficient soil is used to prevent the plants from becoming dry, but a great depth is not necessary. After the

trench has been filled a thorough watering is given to settle the soil and to bring it in close contact with the roots. Plants of the strawberry, too, may be heeled-in, but a shady place should be selected for them, and their crowns must not be buried. The leaf surface should be reduced and a thorough watering given. Attention should be drawn to the fact that heeling-in plants in this way is only an emergency measure and should not be resorted to except where necessary. Plants may be held for two or three weeks or more in this condition where delivery is made early in the spring, but the planting should be done as soon as possible after the plants arrive.

When to Plant and to Transplant.—Spring is the best season for the planting and the transplanting of fruits in the prairie climate. While very satisfactory in less severe climates, autumn planting is very uncertain on the prairies. Even where autumn planting is successful spring planting is preferable. For plants of all the hardy fruits, excepting the strawberry, early spring planting is more satisfactory than planting late in the spring. The mortality resulting when the planting and transplanting are done in April is usually low while the mortality resulting when these are delayed until May is frequently considerably higher. Planting early in May is more successful than planting late in May. Plants that are set early become well established before warm weather arrives and induces top growth to take place, while plants set late are frequently forced into growth by high temperatures before proper connection with the earth has been made. Early spring planting, therefore, should be practised for all fruits, excepting the strawberry, where conditions will permit it.

Plants of the strawberry are usually transplanted the second or third week in May. By that time the plants will have made some growth and this delay in planting permits the selection of strong, vigorous runners that have escaped winter and early spring injury.

Setting the Plants.—Immediately after the plants have been removed from the vessel containing water, or have been uncovered where heeled-in, the planting should be done. The roots must not be allowed to become dry during the planting operations and a moist covering must be provided. Two or three thicknesses of wet burlap wrapped around the roots usually make ample covering for a short time and where only a few plants are being set this should be satisfactory. A better plan is that of using a tub, partially filled with water, on a

wheelbarrow or other means of conveyance and keeping the roots submerged while the holes are being prepared. The use of a mixture of clay and water in a tub is an advantage in that this mixture will keep exposed roots in a moist condition longer than will water alone. The tub method is satisfactory even where many plants are to be set.

The holes to receive the plants should be made just before the planting is to be done. Where deep holes are required and where the good soil is shallow the surface soil and the subsoil should be kept separate. These holes should be sufficiently large to permit the spreading of the roots well. They should be sufficiently deep to permit the use of a few inches of surface soil below the plant and to permit the setting of the plant about one inch deeper than it stood formerly. For a one-year-old apple or plum tree a hole from eighteen to twenty-four inches in diameter and from nine to twelve inches deep should be satisfactory.

In order for the plant to grow, the plant's roots must be in close contact with the soil. To be able to absorb moisture and the necessary elements from the soil in quantities, the roots must be supplied with root hairs, and to obtain these materials these hairs must be in contact with the fine soil particles. Very fine surface soil should, therefore, be worked in around the roots to fill all cavities. Where trees and shrubs are being planted, great care should be exercised to fill the cavity that is likely to remain below the crown or the point where the roots and the stem meet. The soil should be thoroughly firmed and no large air spaces should remain. In all cases surface soil should be used to cover the roots. After the roots have been well covered, and before the hole has been filled with soil, a thorough watering should be given where possible. If the soil is inclined to be dry, it is very necessary to use water and to use it freely. Water applied at this time not only moistens well the soil around the roots, but it settles the soil and brings it in close contact with the roots of the plant at all points. A second watering can be given to advantage. It is important, as already stated, to fill the cavities around the roots and the free use of water is one of the most effective methods of accomplishing this end. After the water has disappeared from the hole, soil should be added and firmed. The surface soil, however, should be left loose to serve as a mulch, and a slight depression should remain around the plant.

Pruning at Planting Time.—All fruit plants require at least some pruning either just before or immediately after

being planted. The latter time is the better as the needs of a given plant can be determined more easily when the plant is in place than before.

Pruning at this time serves a twofold purpose. In the first place, it assists nature in the restoration of a balance between the roots and the parts above the ground surface. A well-established plant maintains a balance between the parts above ground and the parts below ground. When such a plant is moved a large part of its root system is destroyed and the balance established by nature is disturbed. The much-reduced root system is no longer able, in the majority of cases, to meet the demands made upon it by the parts above ground. Where no assistance is given, nature takes steps at once to restore this balance by withholding food materials, which are drawn from the soil by the plant, from portions of the exposed parts. In many cases the balance is restored and the plant grows but in many cases failure results and the plant dies. Much can be done in assisting nature to restore this balance by severe pruning at planting time. In the second place, proper pruning at planting time in certain of the fruits induces the development of the type of plant desired. In apples and plums to be grown in severe climates, for instance, a bush type of plant is demanded. Severe cutting back at planting time in these cases not only assists nature in restoring the balance between root and top, but results, when care is exercised, in the development of the bush-type of plant. The amount of pruning to be given will be discussed under the various fruits, respectively.

The pruning should be done with a sharp tool and a clean cut should be made. For stems up to one-half inch in diameter a secateur, a small pruning-shear, operated with one hand may be used and for larger stems a fine-toothed saw is satisfactory. The cut should be made in such a direction that water will drain off the surface and not be a source of danger to the exposed tissues. The surface of the cut should be made as smooth as possible.

Treatment of Wounds.—When exposed to the atmosphere inner tissues dry out and killing back occurs. The amount of killing back occurring when stems are pruned and not treated usually depends upon the size of the wound. Where the wounds are small the stem may be killed back not more than one-half inch, but where the wounds are large killing back a distance of two inches or more is not uncommon. The dead tissue decays eventually and a pocket in which water is held after a rain is usually formed. Destruction of some of

the living tissues may take place later as a result of this and the plant may be weakened greatly.

Killing back in cut stems may be reduced to a minimum by suitable wound treatments. To be effective, the treatment must be such that the wounds are covered by some agent that will not injure the tissues and that will prevent drying. Several compounds have been used with varying degrees of success but one of the most satisfactory found for use in ordinary pruning is grafting-wax. Either the liquid form or the common form may be used. Where such are not available melted parawax may be applied with a brush. These are harmless to the plant, are easily applied and give good protection to the exposed inner tissues. Only a thin layer is required—that necessary to seal the wound well. This material should be applied immediately after the wound has been made and before appreciable drying has taken place.

CHAPTER IV

THE GARDEN AREA

THE choice of a suitable area is of fundamental importance in the growing of fruits. While little or no choice may be had in many cases, especially on the smaller properties, alternatives are possible in the majority of cases on the farm. One area may be very suitable and may be capable of supporting well the various crops to be grown, while another area with some advantages over the former may be very unsuitable in some respects and any efforts made to grow certain fruits on it would be without return. It is very important to choose for the fruit garden an area that will produce good crops and that will give satisfaction in the greatest measure possible.

SIZE OF AREA NECESSARY

The area to be used as a fruit garden should be as large as possible up to the point where the products can no longer be used to advantage. The place at which this point is reached depends upon numerous factors and it is not possible to state where unless much information is available. On the ordinary town or city property, and where the family is of average size, this point would probably never be reached. In the country a plot from one acre to two acres in extent can usually be employed to advantage where both fruits and vegetables in good variety are to be grown. One-half of this would be required for fruits and the remainder for vegetables. This would be allowing an abundance of most things grown but the margin of safety would be no wider than it should be where land is plentiful. In sections where the precipitation is low a larger area may be necessary, however. Summer-fallowing a portion each year to be used for annual crops the year following is good practice in such sections and where this is to be done the area should be increased accordingly.

SOIL

Much depends in fruit growing upon the nature of the soil to be used for the plantation. Light sandy soils warm

up quickly in the spring and are frequently referred to as "rapid" soils. Such soils have low water-holding capacity, however, and lose their moisture readily during hot dry weather. Heavy soils, on the other hand, warm up slowly in the spring, have high water-holding capacity and retain their moisture well during dry periods. For early vegetables, for instance, and for certain other vegetables demanding high temperatures, a sandy soil has a distinct advantage but this advantage may be offset by the shortage of moisture that is likely to be found unless irrigation can be practised. Owing to its slowness a very heavy soil, on the other hand, may prevent the successful culture of certain plants that are desired. The best soil for the majority of fruit crops to be grown in the average garden is one that is neither very heavy nor very light, that is high in organic matter and that is underlaid by a clay subsoil. A rich, medium loam possesses some of the good qualities of both the light and the heavy soils and meets the requirements of most of our common fruit and vegetable plants.

Depth of soil is an important consideration. Most plants thrive better in a deep soil than in a shallow soil. Shallow soils will sometimes produce fair crops for a short time but such soils are not dependable over a long period and are not suitable for many crops even when new. In certain sections the small fruits are doing reasonably well with a surface soil only four to six inches in depth but it is doubtful that the tree fruits would thrive under those conditions. If the best results are to be obtained with fruits in general the surface soil should have a depth of nine to twelve inches at least.

Soils containing much "alkali" should be avoided where possible. Seldom does a soil showing the slightest whitish deposit on its dried surface make a satisfactory area for fruits. While much can be done toward ameliorating such a soil the selection of an area containing even a small amount of "alkali" is permissible only when necessity demands it.

Exposure

The matter of exposure should not be disregarded. In many places on the prairies one may note the scanty vegetation on a southern slope and the abundant vegetation on a northern slope. This condition is not the result of the workings of chance but has a definite cause. Insolation—absorption of solar heat—is much greater on a southern slope than on a northern slope and the soil on the former warms up more

quickly in the spring than does the soil on the latter and remains warmer during the summer months. This undue warming up of the soil early in the spring usually results in the forcing of plants on the area into growth before spring frosts are over and various forms of frost injury to the vegetation occur. Further, the higher temperatures result in the more rapid drying of the soil and soon the supply of moisture, in some cases at least, becomes insufficient to support a normal vegetation. These conditions are more marked in the case of a steep slope than in one that is shallow. In general a southern slope is to be avoided for the fruit plantation. Between an eastern slope and a western slope the difference may not be great but the former is the better. An eastern slope is more desirable even than a northern slope. If only slight, a southern slope may be used safely. In relatively few instances, however, does a choice exist. In most cases the land on the prairie is flat or reasonably so and the element of exposure with reference to slope seldom becomes a factor governing the choice of a location for the fruit garden.

Drainage

Good surface drainage is essential. At no time during the year should water lie on the surface of any part of the area to be used. While water on the area for a time in the spring when the plants are dormant may not be harmful, conditions responsible for the inability of excessive surface moisture to escape at that time are likely to result in poor surface drainage during the summer also. A somewhat low-lying area where the soil is naturally moist is advantageous for certain fruit crops but the ground should be sufficiently high even in this case to permit the escape of surplus surface moisture at all seasons.

Convenience

To be of the maximum value the fruit garden must be conveniently located. A garden of this type may be visited to advantage several times each day during certain seasons and unless it is near the house these frequent visits will not be made. When its location precludes frequent visits, the garden loses much of its interest and is not likely to supply the variety of fresh fruits that can be used daily to increase the healthfulness of the diet.

A good location for the fruit plantation from the standpoint of convenience is adjoining the home grounds. There it is only a few steps from the back door of the house and is readily accessible at all times. In this location it need not detract in the least from the appearance of the home grounds and it should be of the greatest use possible.

The Necessity for Shelter

Shelter is of prime importance for the prairie fruit garden. To be successful, the garden on the prairies must have abundance of protection from the gales that frequently sweep the plains. It is true that some fruit plants can be grown without protection but even the most wind-resistant plants will thrive better with protection than without it. Certain plants that cannot be grown successfully without shelter can be grown reasonably well when protection is provided. This shelter is required not only during the spring, summer and autumn months but during the winter also.

Shelter and Moisture in the Garden Area.—Shelter facilitates the growing of fruits in various ways. An important value lies in its ability to increase the supply of moisture available to the fruit plants being grown. This increase is brought about through the melting snow trapped in the plantation by the trees surrounding the area and through the reduction in evaporation losses. In many cases large quantities of snow drift through the shelter and remain in the plantation to be melted in the spring and to add moisture. Even where little snow drifts in, shelter prevents the removal of that falling in the plantation and thus provides an increase in the supply of moisture for the area.

Evaporation losses are reduced through the ability of the shelter to reduce the rate of air movement. With a reduction in the rate of air movement losses in moisture both from the soil and the plants are reduced and the efficiency of the moisture present in the soil is greatly increased. Evaporation rates with an air temperature of 84° F. and with a relative humidity of fifty (air 50 per cent saturated) were found by Russell of the U.S. Signal Service to be as follows:

Evaporation	with air	moving at	5	miles	per hour	was	2·2 x calm
,,	,,	,,	10	,,	,,		3·8 x ,,
,,	,,	,,	15	,,	,,		4·9 x ,,
,,	,,	,,	20	,,	,,		5·7 x ,,
,,	,,	,,	25	,,	,,		6·1 x ,,
,,	,,	,,	30	,,	,,		6·3 x ,,

Tree belts have reduced the velocity of wind from twenty-five miles per hour to five miles per hour at a point two hundred feet leeward. Evaporation losses in a field thirty rods wide in Nebraska were reduced 30 to 70 per cent by a windbreak of trees. Similar savings might be expected in the plains of Canada. With moisture an important limiting factor, fruits might well be expected to do better in the presence of good shelter than in its absence.

FIG. 18.—STANDARD APPLES IN A SASKATCHEWAN FRUIT PLANTATION

Success in fruit growing is possible with good shelter. This photograph shows a tree of Wealthy apple carrying at least one bushel of fruit in the plantation of Mr. Frank Boskill, Rutland, Saskatchewan, in 1935. See text, p. 73.

Shelter and Injury to Fruit Plants.—Shelter has virtue in reducing mechanical and winter injuries in fruit plants. In an unprotected area such plants usually suffer considerably at certain seasons through having their branches whipped by high winds. This is very marked in tree fruits. Damage to the flowers and to the fruits may be sufficient to reduce the crop greatly. Well-sheltered fruit plants, on the other hand, seldom show much injury of this sort. Much of the winter injury occurring in fruit plants results from the drying out of the tissues of the parts concerned. In many cases the water lost through evaporation from the bark of

the plant cannot be replaced rapidly enough by the roots, and death of the exposed parts concerned takes place, as a result of the drying. Plants exposed to winds lose more water than do those protected and this difference is sufficient at times to result in serious injury in the former case and little or no injury in the latter. Shelter may thus permit the growing of certain fruits that could not be grown otherwise.

SUITABLE SHELTERS FOR THE FRUIT GARDEN

Many different types of shelters may be found satisfactory for the garden area. Shelters from a single-row hedge to a wide belt consisting of eight to ten rows of trees or more are found in use and all types have been reported successful. Any shelter that will effectively change the course of the wind and that will suit the special conditions concerned may be used.

A wide Shelter-belt.—An excellent arrangement is that where a shelter-belt encloses the area occupied by the farm buildings and grounds and where provision has been made in this area for the fruit and vegetable garden. In this case the main shelter-belt affords the garden area good protection and the use of a single-row hedge on the open sides of the garden area will give any additional protection that is necessary.

An example of such a plan may be found in Fig. 19. In this the entire area has a hedge of *Caragana arborescens* or Siberian pea-tree as a boundary. This hedge is untrimmed excepting the portion directly in front of the house which is trimmed. One hundred feet in from this hedge, on three sides, is the main belt consisting of eight rows of trees and inside this belt are the fruit and vegetable garden, the various buildings and the grounds. On the north and on the west, the garden area has boundaries of untrimmed caragana. The exposure is east but a similar lay-out would be satisfactory if the exposure were south. If the exposure were either north or west by necessity, heavier plantings along the front boundary of the property would be necessary.

The main belt consists of two rows of Russian poplar, two rows of green ash, two rows of American elm and two rows of white spruce. The rapidly growing and short-lived trees are on one side of the belt and the slowly growing and long-lived trees on the other side. The poplars have been placed on the outside so that they can be removed readily at an appropriate time and so that the land occupied by

them can be used for crops along with the wide strip between the caragana hedge and the wide belt. The evergreens have been placed on the inside of the belt to receive the protection of the other trees used and to give the maximum of beauty when viewed from the sheltered area inside.

Plants of kinds other than those mentioned may be used for the shelter-belt. While caragana is suggested for the hedge, plants of some other kind may be employed for this section of the shelter. For low-lying areas that become very

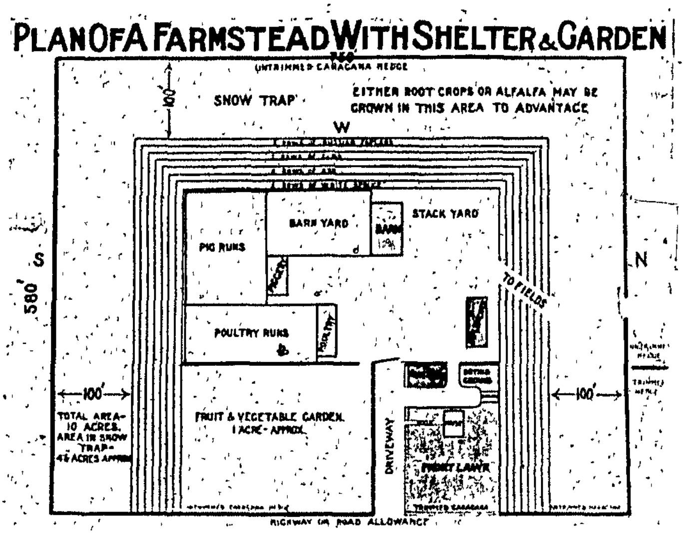

FIG. 19.—A PRACTICABLE FARMSTEAD PLAN

Good shelter is a prime requisite in the successful culture of fruits. In a well-planned farmstead, provision for the fruit plantation in a well-sheltered area is made.

moist at times caragana should not be used as this plant will not tolerate "wet feet". For such conditions some water-tolerant plant should be employed and a species of willow might be used to advantage. A combination of caragana and willow might be used if necessary—caragana on the high land and willow on the low-lying land. The main belt may consist of species other than those suggested or of fewer species if desired. North-west poplar is more desirable than Russian poplar in many cases. It is advisable, however, to have some variety and to use a combination of rapidly growing trees, for quick effect, with slowly growing and long-lived forms to provide shelter in later years. Further, it is well to keep the various kinds in rows by themselves.

The spacings allowed in this case are more generous than those usually given. In the untrimmed caragana hedge a single row of plants is used and the plants are given four-foot spacings. In the short section of trimmed hedge the plants are placed only six inches apart. Spacings of eight to twelve feet or more are recommended for the trees in the wide section of the belt. A convenient arrangement is to have the trees eight to ten feet apart in the row and the rows twelve feet apart in the permanent section of the belt. Spacings of ten to twelve feet each way would be satisfactory, however. The temporary trees could be planted eight feet apart each way and a distance of twelve feet left between the last row of permanent trees and the first row of temporary trees.

A narrow Shelter-belt.—A much simpler shelter than that described above is one consisting merely of a double row of caragana or of some other kind of tree. In this case the shelter might surround the garden area only or it might surround the area on which the buildings stand and the garden area together. The plants should be placed four feet apart in the row and the rows four feet apart. The plants in one row should alternate with those in the other row. Such a shelter is very effective and it occupies the minimum amount of land that a protective belt could be expected to occupy.

A temporary Belt.—Delay in the culture of fruits while a tree-shelter is being obtained is not necessary. While it is desirable to have a well-established shelter-belt around the area to be used for a garden before any planting is done it is possible to start the fruits and the trees for shelter at the same time. In such a case a temporary shelter should be employed. Double rows of sunflowers or of hemp running north and south and placed at intervals of twenty to twenty-five feet may be used in such a case while the permanent belt is developing. The heads of the sunflower plants should be removed in the fall and only the stems left standing over winter. Such temporary shelter is not as satisfactory as permanent shelter and its use is to be considered an emergency measure for employment only while the trees that are to form the permanent shelter are undergoing the earlier stages of development.

Preparation of Soil

Proper preparation of the soil is an important stone in the foundation of success in fruit gardening. Before any

planting has been done the entire area should be given treatments that will improve the soil and that will provide the best conditions possible for growth. Once the planting has been done amelioration of the soil is difficult and treatments given at that time should be considered supplementary only.

Summer-fallowing for at least one year before planting is good practice. Where the land has been cropped heavily, summer-fallowing for two years might be desirable. The ploughing should be done early in the season, not later than May, and this should be done to the depth of nine or ten inches where conditions will permit it. If the surface soil is shallow, ploughing to the depth mentioned might result in the bringing of considerable subsoil to the surface and lighter ploughing may be necessary. A heavy application of stable manure should be made to the area before the ploughing is done and this manure ploughed in. From twenty-five to fifty loads to the acre is not an excessive application. Lighter soils and those lacking in organic matter could receive even heavier applications than this. Stable manure is excellent for use in counteracting "alkali" and to any spots showing "alkali" more manure should be applied.

Immediately after being ploughed the area should be worked down well with the disk. Harrowing may be necessary to assist in settling the soil and levelling the surface. Diskings should be given as often as are necessary to keep down weeds and to conserve moisture. The use of the harrow after each disking is usually desirable to level the surface and to reduce the area exposed to the drying influences of the wind and atmosphere to a minimum.

In the spring of planting, the area should be cultivated as early as possible. Excessive cultivation should be avoided, however, but sufficient should be given to break the crust formed over the surface during the winter and early spring and to retard evaporation. Where soil drifting is a problem this practice might require modification.

Use of Commercial Fertilizers

Up to the present, commercial fertilizers have not been used extensively on garden crops in the prairie provinces. One assumption has been that most garden soils are naturally rich and that the use of fertilizer was unnecessary. Another assumption has been that barnyard manure is the best fertilizer and where the use of a fertilizer was deemed advisable this was applied. In a few cases, especially on the

smaller gardens, commercial fertilizers have been used with varying degrees of success.

Since they have given good results on field crops in many cases commercial fertilizers should have considerable value for garden crops. The success to be obtained from the use of a commercial fertilizer is influenced much by the amount of moisture available, however, and the type of soil. To become available to the plant the fertilizer must go into solution and in dry years the amount of moisture present may be sufficient to take into solution only a small amount of the compound or compounds used. In seasons of abundant moisture commercial fertilizers of the proper kinds can be counted upon to give good results. Since lighter soils are usually lower in organic matter and in reserve plant food than are the heavier soils the former are likely to give a greater response than the latter to applications of suitable commercial fertilizers.

The grower of garden plants in the prairie provinces who proposes to use commercial fertilizer should do so knowing that little information on the subject is available. He should approach the matter as an experimentalist and endeavour to give this type of fertilizer a fair test under his particular conditions. It would be advisable to use it on only a small area at first in certain cases and to increase its use only after experience justified doing so. In using the fertilizers selected he should follow the directions supplied either by the manufacturer or by someone with experience in the use of fertilizers.

Kinds of Commercial Fertilizers.—While many kinds of fertilizer are available, those supplying readily available nitrogen and phosphorus are like to prove the most promising or to give the best results in the prairie provinces of Canada. In nitrogen-bearing fertilizers of this class sodium nitrate, carrying about 16 per cent nitrogen, and ammonium sulphate, carrying about 20 per cent of this element, are two of the best. Superphosphate carrying about 16 per cent phosphoric acid, and triple superphosphate, carrying about 48 per cent phosphoric acid, are two of the leading phosphorus-carrying fertilizers. A very common and very useful fertilizer carrying both nitrogen and phosphorus is found in ammonium phosphate. It contains about 10 per cent nitrogen and about 48 per cent phosphoric acid. All the fertilizers mentioned are dependable, and where the use of fertilizers is indicated these are recommended. All are readily obtainable in western Canada.

It is impossible to state definitely which fertilizer or

fertilizers will give the maximum returns under a given set of conditions. Experimentation alone will determine this. For quick action in a nitrogenous fertilizer, nitrate of soda is excellent. Where rapid action in a nitrogenous fertilizer is not required ammonium sulphate should be used. A good combination in certain cases at least is a moderate application each of sodium nitrate and ammonium phosphate at the same time. The nitrogen from sodium nitrate is immediately available and before this nitrogen has been absorbed by the plant the nitrogen in the combination fertilizer will be readily available. The phosphorus added in the combination fertilizer should prove an additional stimulant to the plant.

Method of Application.—Method of application has an important relation to results obtained. To be of value to the plant a fertilizer must be in solution. During a dry summer the moisture content of the soil may be too low to permit solution to take place and much of the fertilizer may remain in the undissolved condition. In such a case the plants cannot benefit to the full extent and a fertilizer may be condemned before it has been given a fair trial. While the usual method of applying commercial fertilizers is that of placing the salt in the soil near the seed or near the roots of the plant, the best method is that of dissolving the salts first in water and then applying the solution to the soil. This usually provides a more uniform distribution of the fertilizer in the soil and tends to prevent the burning frequently resulting from the application of the undissolved salt. Such a method is practicable on a small scale only but it should be employed where conditions will permit its use. The greater the dilution used, to a certain point, the better the results obtained should be, but there is a practicable limit to dilution. Good results usually follow when a dilution of one pound of the salt to two gallons of water is made but greater dilutions should be made where possible. Fertilizers used at the dilution mentioned are not likely to burn any part of the plant and can be used without fear of injury to the plant provided the total quantities given are not excessive.

CHAPTER V

THE APPLE

PERHAPS no other fruit is as universally popular as the apple. It meets with favour in all lands and few people are without a fondness for it either in the raw condition or preserved. In many homes in Canada and United States it is a staple article of diet and constitutes the major part of the fresh fruit consumed.

Trees of this fruit should be included in the prairie fruit plantation. Owing to various reasons many people in the rural sections of the Great Plains area fail to use in quantities this healthful and appetizing fruit. The home fruit plantation is a convenient source of this fruit and a home-grown supply tends to stimulate its use. It is true that relatively few varieties of the apple are suitable for planting under the extreme conditions prevailing in most parts of the Canadian prairies but sufficient can be found to add variety to the collection of fruits and to provide at least a portion of the family's needs in this fruit.

BOTANY

The apple belongs to the genus *Malus*. The plants are either trees or shrubs that produce leaf-buds and mixed buds or leaf- and flower-buds combined. Leaf-buds are usually produced on rapidly growing shoots while mixed buds are found chiefly on the ends of very short branches which are known as spurs. In certain varieties, however, mixed buds appear in the axils of leaves on shoots of the current season's growth and in some cases even the terminal buds of the new growth are mixed. Mixed buds are usually stout and rounded at the tips while leaf-buds are slender and pointed at the tips. The flowers are produced in cymes—flat-topped clusters with the centre flower opening first—which appear after the leaves. The sepals and petals each number five; the stamens are many and the ovary is usually five-celled with five styles. The normal number of ovules in each cell is two but in some cases as many as four or more are found, as in varieties the fruit of which consistently produces many seeds. The fruit is known as a pome.

Important Species.—Few species are important in the case of the apple. From *Malus malus*, which is believed to be a native of Europe and southern Asia, have come our standard large-fruited varieties. This species varies considerably in hardiness but even the hardiest varieties are not dependable in western Canada. The Siberian Crab (*Malus baccata*), a native of Siberia, northern China and Manchuria, is considered the hardiest apple known and the plants have proved hardy in all the settled parts of the West in which efforts to grow them have been made. Trees of this crab are thriving and fruiting at the Roman Catholic Mission at Fort Resolution on Great Slave Lake where the temperature dropped to $-60°$ F. during the winter of 1933–34. The fruit is small and unpalatable, however. The Common Crab (*Malus prunifolia*) is hardier than *M. malus* but less hardy than *M. baccata*. It is found growing in China and is believed to be a hybrid between *M. malus* and *M. baccata*. The fruit of cultivated varieties of this species is of medium size and in most cases is very palatable. Much hybridizing has been done between *M. malus* and *M. baccata* and seedlings producing fruit of fair size and possessing hardiness in a marked degree have been obtained. Three species native to America are of some importance. These are the American Crab (*Malus coronaria*), the Western Crab (*Malus ioensis*) and the Soulard Crab (*Malus soulardii*). The last mentioned is thought to be a natural hybrid between *M. malus* and *M. ioensis*). These native crabs have been utilized to some extent in breeding work but their contribution to present-day varieties has been very small. *Malus ioensis* and *M. soulardii* are found as far north as southern Minnesota and South Dakota but all are too tender for the more rigorous climate of the prairie provinces of Canada.

Development of Apple

According to De Candolle the common apple has been cultivated in Europe since prehistoric times. Little information as to the quality of the fruit produced in early times by this species is available but there is reason to believe that much of it was of fair size and of fair quality at least. This species was introduced to America early in the seventeenth century by French settlers. Definite record of Champlain having brought fruit trees to Quebec from France in 1608 has been found and it is not unlikely that apples were included. The first plantings in Canada were made at this time along the

banks of the St. Lawrence river and in Acadia, now Nova Scotia. It is believed that the varieties first brought into New York State came chiefly from Holland. Propagation at first was mainly by seeds but records show that grafting was done in Virginia as early as 1647. The best seedlings obtained were perpetuated and a long list of superior varieties was gradually built up. In 1869 there were 1856 varieties listed as grown in America and of these 1099 were of American origin. Since then many new varieties have been introduced and over three thousand varieties are known in America at the present time.

European Varieties in America.—Few of the varieties now grown in America are of European origin. American varieties have for the most part proved superior to those of European origin and have replaced the latter to a very large extent. A few European varieties are remaining, however, and Oldenburg, one of the best known early apples grown in Canada, is of Russian origin. Blushed Calville, Charlamoff, Tetofsky and Hibernal also, which frequently appear in variety lists for western Canada, are varieties that originated in Russia. The Fameuse or "Snow", a much-sought dessert apple in certain sections of America, is believed to have been introduced from France. The Gravenstein, a variety extensively grown in Nova Scotia, is of European origin. Even though these and other European varieties are popular in certain sections the percentage of the total crop represented by them is small and the main crop consists chiefly of varieties originating in America.

When American Varieties originated.—Present-day varieties grown in America owe their origin to widely different times. The variety known as Early Harvest is believed to have originated in New York State and records show that it has been grown since the year 1700. Information as to the exact date of the discovery of Newton Pippin appears not to be available but records reveal that it came into existence prior to 1759. The Baldwin, a very popular variety a few years ago and one which is still grown considerably, was discovered in 1793. McIntosh Red, probably the most popular variety grown in America today, was discovered in 1796. Fruit from the original tree of Grimes Golden, a very popular dessert variety, reached New Orleans traders as early as 1804. Northern Spy was introduced early in the 1800's. Cox's Orange Pippin originated about 1830 and Wealthy was first described in 1869. Patten's Greening was first described in 1885 and Delicious was introduced in 1895. The original

tree of Melba fruited for the first time in 1908 and it was not until some years later that it was introduced. Anoka, Haralson and certain other varieties are very recent introductions.

Early Apple-breeding in Canada.—The earliest recorded apple-breeding in Canada was that done by Charles Arnold

FIG. 20.—A GOOD SPECIMEN OF OSMAN CRAB

Note the bush type of plant that is desirable for use in the cold and windy sections of the West.

of Paris, Ontario. Crosses were made between Wagener and Northern Spy and in 1873 he exhibited fruit of eighteen of his hybrids in Boston. One of his seedlings was introduced under the name of Ontario which is being grown to some extent commercially at the present time. Francis Peabody Sharp of Upper Woodstock, New Brunswick, undertook the hybridization of apples in 1869. The parents used in his work were New Brunswicker, a variety name which was probably

synonymous with Duchess of Oldenburg, and Fameuse. Of his originations that were named and introduced Crimson Beauty is the best known. Early in the 1870's William Saunders, at that time a druggist in London, Ontario, began the breeding of fruits on his farm near the city. This work proved to be the foundation of very important work that was to follow. About 1885 apple-breeding was begun at the Central Experimental Farm, Ottawa, Ontario, and this has been continued to the present day.

Development of Hardy Crab-apples in Canada.—With a view to obtaining hardy apples for the Canadian North-west Dr. William Saunders, Director of the Central Experimental Farm, Ottawa, began a project in 1887. In that year he imported from Russia seed of *Malus baccata* to be used in the growing of seedlings for testing under the severe climatic conditions of the prairie provinces. The seedlings were grown at branch experimental stations in Manitoba and Saskatchewan and were soon found to possess the hardiness necessary for those regions. In 1894 improvement work was begun and crosses were made between this crab and standard varieties. Twenty-one varieties of the standard apple were used as male parents in this early work and approximately eight hundred seedlings were grown. Encouragement was received when the first seedlings resulting from these crosses fruited and soon the project was acclaimed successful, in a measure at least. Some of the seedlings obtained had the necessary hardiness and produced fruit from one and one-half to one and three-quarters inches in diameter and which was of very fair quality. A number of hardy crab-apples recommended for the Canadian West at the present time resulted directly from this early work of Dr. Saunders. Osman, Columbia, Magnus, Pioneer and Sylvia, which are crab-apples of considerable merit, are representatives of this group of first generation hybrids.

So encouraging were the results from the first crossings that Saunders undertook the introduction of a second infusion of blood of the standard apple into the hardy crab. This phase of the fruit improvement project was begun in 1904 and records show that two hundred and twenty-three seedlings were grown. Improvement in size and quality in the fruit was obtained but this was found to be at the expense of hardiness in some degree at least. Several varieties of this generation were introduced and some of the best known are Printosh, Piotosh, Elkhorn, Rosilda and Trail. These varieties appear to be of little value directly in most

sections of the prairie provinces but they may prove of considerable value in apple improvement work.

Later, a third infusion of blood of the standard apple was introduced. Some of the seedlings of this generation that have fruited to date show considerable improvement over the second generation as far as size and quality are concerned, but their degree of hardiness has not been determined as yet. The value of these varieties for the West should be known before many years have passed.

Until twelve years ago nearly all the apple-improvement work for western Canada was being done at the Central Experimental Farm, Ottawa. Since 1923 vigorous programmes for apple improvement have been launched in the prairie provinces and results of this work should be in evidence in the near future. Even now, varieties of western origin are under test and some of these will doubtless prove sufficiently valuable to merit culture. Many thousands of seedlings that have not fruited as yet are being grown and these are almost certain to yield varieties of some value at least. Hybridization is being continued and great progress in the development of hardy apples for the northern part of the Great Plains region should be witnessed during the next fifty years.

Introduction of Siberian Crab.—Mention should be made here of the early introduction to America of the Siberian Crab and of its early use in hybridization on this continent. The exact date of its introduction to America appears not to be known but reference to it is made in American fruit literature of the early part of the nineteenth century. As early as 1870 reference was made in literature to varieties originating from controlled matings between this crab and varieties of the standard apple. Brier and Gibb are two varieties from such matings that originated during the period centring around 1860 and 1870.

Classes of the Apple

For convenience, apples may be divided into two groups. These groups may be designated as "standard" and "crab". Standard apples comprise the large apples of commerce and many other large varieties that are little grown. All, however, are relatively large. Many of these are of good quality, but some have little quality to commend them. Considerable variation in hardiness in this group is found, but even the hardiest are either tender or only partially hardy in the

coldest sections of the Great Plains area. The important use of standard apples is for dessert, but many are used for cooking purposes. Crab-apples are smaller than standard apples, and their quality in general is inferior to that of the group of larger apples. Some of these, however, are fair for dessert and excellent for cooking. Trees of the crab-apple group, as a class, are hardier than trees of the standard group. Great variation with respect to hardiness is found in this group, however, and the tree of the tenderest crab may be less hardy than the tree of the hardiest standard apple. Crab-apples are grown mainly for preserving and for use in jelly-making. Both classes have important places in apple production and in apple consumption.

Varieties for the West

Suitability of Apples and Crab-apples for Canadian Prairies. —Trees of varieties of the standard apple have not to date proved hardy in most districts of the prairie provinces of Canada and this group is not generally recommended for planting in these provinces. In the extreme southern part of Manitoba, which is favoured climatically, standard apples are grown successfully on a commercial scale, and as a result of the apples produced in this section Manitoba is listed as an apple-producing province. In parts of the southern sections of Saskatchewan and Alberta a few standard apples are being grown but the plants have not proved sufficiently hardy to make the venture very certain. In most parts of the Canadian prairie the growing of standard apples is still very much in the experimental stage and it should be regarded as such for the present at least. If the grower has a well-sheltered location for the fruit plantation and will not be disappointed if his trees fail to bear much fruit, a few standard varieties may be tried. By top-grafting standard apples on hardy crabs, one may be able to grow varieties successfully that could not be grown otherwise, but this is a very special method that is practicable in few cases only. Trees of a number of varieties of crab-apples, on the other hand, have sufficient hardiness to be grown in this region and, if a reasonable amount of protection is provided, fruit of this class may be produced in quantities in the prairie home garden.

It is not the intention of the author to discourage the planting of trees of standard apples in the prairie provinces. It is his wish, however, to make clear to the intending planter

that standard apples are not as readily produced as crab-apples. During the later part of the summer of 1935 the author had the pleasure of visiting Mr. Frank Boskill, Rutland, Saskatchewan, who has been growing fruit for some time. In his plantation were trees of the variety Wealthy, each of which was carrying a bushel of apples of good size for the variety. The site of this plantation was ideal, being on a south-eastern slope and having the protection of a range of hills running north-east and south-west. Others too are producing standard apples in fair quantities. Because these few have been successful in bringing to maturity a few apples is not evidence that anyone can produce apples successfully. Where such apples are produced the conditions are good for the district. There are many who have trees of such varieties that produce fruits in such small numbers that the venture is not worth while. Crab-apples should be grown first and standard apples added later to make the plantation more interesting and with a view to having the possible thrill of producing a few large apples under difficult conditions.

Variety for Fruitfulness.—Since named varieties of apples and crab-apples are either partially or wholly self-sterile, the grower must plant trees of two varieties at least to ensure a set of fruit. It is good practice to plant trees of three or four varieties if possible. The greater the number of varieties, the greater are the grower's chances of obtaining satisfactory cross-pollination and a good crop of fruit. A variety sometimes has "off" years when the trees fail to flower. If only two varieties are represented in the plantation and the trees of one variety fail to bloom in a given season, the trees of the other variety are unable to set fruit during that year. Incompatibility between certain varieties exists and if only two varieties are selected poor crops may be obtained because of the unsuitability of one variety to serve as a source of pollen for the other variety. Differences in the blooming season of varieties is found in apples and crab-apples and the difference in this season is sufficiently great between certain varieties to render one an unsatisfactory source of pollen for the other. The need for a greater number of varieties than two is thus evident. The Siberian crab is usually grown from seed and, since no two trees from seed are identical, as many varieties as there are trees will be found in this case. Because of this, two trees or more of this crab will usually fruit when planted together. Trees of other crabs are not grown from seed and consequently plants of different varieties must be planted if fruit is to be obtained. Crab-apples serve as sources of pollen

for standard apples, and standard apples serve as sources of pollen for crab-apples. It is not advisable in most prairie sections, however, to depend on varieties of the standard apple to supply pollen because of the uncertainty of plants of these varieties to produce bloom in sufficient quantities for satisfactory pollination.

STANDARD APPLES. *Hibernal.*—This is believed by some to be the hardest variety of the standard apple in existence but this is doubtful. The fruit is large, somewhat flattened,

FIG. 21.—FRUITING BRANCHES OF MAGNUS CRAB AT CLOSE RANGE

This is a desirable but much neglected crab.

greenish-yellow splashed with dark red and is of fair quality. It is rather late in maturing for most sections of the West. This variety originated in Russia.

Blushed Calville.—At Saskatoon, this variety appears to be somewhat hardier than Hibernal. The fruit is of medium size, somewhat conical, pale yellow with a slight blush and of very fair quality for an apple of its class. It matures from two to three weeks earlier than Hibernal. The tree usually fruits early in its life and the author has harvested fruit from a small tree the year after that of planting, and the tree being only one year from the bud at planting time. This is one of the

most dependable and the most satisfactory standard apples among present-day varieties. This variety too originated in Russia.

Charlamoff.—This is an early-maturing Russian variety. The fruit is above medium in size, is conical and has a yellow skin which is streaked and splashed with red. Its season is short but it is a good dessert apple while at its best.

Other varieties in this class that might be tried are: Patten, Oldenburg (Duchess), Anisette, Perkins, Simbrisk, Pine Grove Red, Antonovka and Haralson. In the extreme southwest part of Saskatchewan, in the Morden and other very favoured areas, Melba, Yellow Transparent, Anoka, Wealthy and other varieties, including the Morden introductions, should be tried.

CRAB-APPLES. *Siberian.*—This is the hardiest apple known and is a very variable form. The fruit is usually from three-eighths of an inch to three-quarters of an inch in diameter, and is usually borne in numerous clusters on the branches. In colour it may be yellow, yellow blushed with crimson, light green blushed with crimson or red. The fruit is of poor quality, but is useful in jelly-making. The tree has been used as an ornamental, and the seedlings make excellent stocks for named varieties. As a source of extreme hardiness this crab is employed frequently as one parent in apple-breeding work. Owing to its susceptibility to Fire-blight, it is not recommended for general use but it should be employed in northern districts to furnish stocks for both crab-apples and standard apples. Certain trees of it appear to be immune to this disease, however, and it is possible that immune forms will be obtainable at some future date.

Dolgo.—Though larger than Siberian this crab is below medium in size and is of fair quality only. The fruit is brilliant scarlet and is excellent for the making of jelly. The tree is reasonably hardy, is usually very productive and is fairly resistant to Fire-blight. This is one of the best jelly crabs. It is a seedling of Siberian and was imported from Russia in 1897 by Professor N. E. Hansen and was introduced in 1917.

Alexis.—While almost identical with Dolgo in appearance this crab appears to be somewhat more vigorous than the latter. The fruit is of similar size and of similar shape to that of Dolgo but matures two or three days later. It has shown only very slight susceptibility to Fire-blight at Saskatoon. This crab was one of many seedlings grown by N. E. Hansen from seed of *Malus baccata* obtained from Russia. It was introduced in 1919.

Osman.—This is one of the hardiest of the larger crabs. The tree is hardy and is reasonably productive. The fruit is above medium size for a crab, is yellow splashed with crimson and is of very good quality. In season it is moderately early and the fruit ripens before the end of August. Thus far the tree has been almost immune to Fire-blight. This is a crab-apple that is strongly recommended. It is a first-generation hybrid between Siberian crab and Osimoe, a standard apple, and was originated by Dr. Saunders.

Columbia.—For some years this variety and Osman have been considered the hardiest of the Saunders' first-generation hybrids. The tree is very hardy, is a strong grower and is very productive. The fruit is somewhat conical in shape, of medium size, of very fair quality, a good cooker and has good keeping qualities. Its normal colour at maturity is red though much of the fruit harvested on the prairies is either yellow or yellow tinged with red. The tree possesses marked resistance to Fire-blight. The fruit matures about ten days later than that of Osman. This is a very dependable variety for use in cold sections. As parents it had Siberian crab and Broad Green.

Sylvia.—This is the earliest maturing crab on the list. The fruit is of medium size and of good quality when at its best. It remains in prime condition for a few days only and then becomes mealy. The skin is pale yellow in colour. The tree is moderately hardy, is very productive and is evidently either immune or very resistant to Fire-blight. This variety is desirable but should be used sparingly in a plantation. This too is a first-generation hybrid produced by Dr. Saunders and resulted from a cross between Siberian and Yellow Transparent.

Magnus.—Though one of Saunders' best hybrids, this variety has fallen into neglect. The fruit is of good size and of good quality and matures about the same time as Osman. Its skin is pale yellow overlaid with light-red. The tree is hardy, very productive and has shown no tendency to "blight". Experience at Saskatoon indicates that this is an outstanding crab-apple. The parentage is *Malus prunifolia* and Simbrisk No. 9, a Russian standard apple.

Florence.—This is one of the larger crabs and was introduced by Peter Gideon, Excelsior, Minnesota. Its parentage is unknown. It has yellowish skin overspread by light-red on the side exposed to the sun. The fruit is of medium quality only, the flesh being somewhat coarse, very firm and with considerable astringency. It is a good cooker, however, and makes excellent jelly. The tree is hardy and very resistant to

Fire-blight but is only moderately productive. While less desirable than certain other crabs, this variety is worthy of a prominent place on lists of recommended fruits for the Great Plains region.

Pioneer.—While smaller than that of most of the other varieties on the list the fruit of Pioneer has good flavour and is of good quality. The tree appears to be immune to Fire-blight, is hardy, is a strong grower and a good fruiter. This is a

FIG. 22.—A TREE OF SYLVIA CRAB IN BLOOM

Saunders hybrid of the first generation with Siberian Crab and Tetofsky as parents.

Adam.—Though not generally known, this variety is destined to have a prominent place on variety lists for sections with a severe winter climate and with low precipitation. The tree is very hardy, is very productive and has shown only slight tendency to blight to date. The fruit is of medium size, and it carries its size well even in dry years. Its general quality is very fair and its cooking qualities are good. When fully ripe the fruit is beautifully coloured and much of the colour is carried to the preserves and jelly made from it. It is a seedling of Siberian Crab and was originated and introduced by W. J. Boughen, Valley River, Manitoba.

Bedford, Garnet and Amur are three very fair crabs that are markedly resistant to Fire-blight and that are grown to some extent. Bedford and Amur are more desirable than Garnet, the last-mentioned being primarily a jelly crab and ripening rather late.

Transcendent, Mecca, Prince, Jewel, Charles and Olga, which frequently appear on fruit lists and which are desirable crab-apples in some respects, are not recommended because of their marked susceptibility to Fire-blight.

Hopa is a hardy red-flowered crab producing small red-fleshed fruit that is grown to some extent. Its chief use is as an ornamental and for a large shrub it is unexcelled.

Trail, Printosh, Piotosh, Angus and Rosilda are among the best of the hardier group of Saunders' second-generation crab-apples. These might be tried where greater variety is desired and where the yield of fruit is not important. The fruits of these are very large for crab-apples and are of good quality but the trees cannot be rated fully hardy. Trail has proved to be hardier than any of the other varieties of this group in the University plantation and its fruit is excellent both for eating and cooking purposes. Other varieties in this group that are of importance are: Redman, Wapella, Elkhorn, McPrince and Martin. All these can be expected to do better in southern districts than in those northern. Some of these varieties are reported to be doing well in isolated cases across the prairies but they are of questionable value in most parts of the West outside the very favoured sections and are not recommended for general planting. Success with these is more easily attained than with standard apples, however.

Propagation

Named varieties of the apple and crab-apple are propagated by budding and grafting. Budding has been very satisfactory in the West and, under prairie conditions, it appears to be a better method of propagating these fruits than is grafting. Seedlings of Siberian crab should be used as stocks. The Siberian crab is usually propagated by seed, though special forms of it are propagated by budding.

It should be understood that seed may be used in the propagation of apples and crab-apples but that named varieties will not come true from seed. Seedlings are likely to be inferior to the female parent or the variety producing the seeds. There is, however, a chance of a superior variety being

evolved in the growing of seedlings and it has been this that has induced contributors of apple varieties to grow the seedlings that have resulted in the long list of varieties now in existence.

Seeds to be used in the growing of seedlings should be taken from the fruits before planting. The fresh fruits may be cut open individually by hand and the seeds removed or the decayed fruits may be crushed and the seeds separated from the flesh through the medium of water. The seeds are heavier than water and will settle to the bottom of the container while most of the decayed flesh will float.

After being removed from the fruits the seeds may be spread out and allowed to dry or they may be mixed with a moist medium to prevent drying. If the germination of every seed possible is not necessary, the drying method may be adopted and the dried seeds stored in bags or in envelopes until planting time or until the after-ripening is to begin. If, on the other hand, the maximum germination is desired, drying must not be permitted and the seeds should start the after-ripening process at once.

A simple method, and one that is very satisfactory, is that of allowing the seeds to remain in the fruit until the latter part of October when they are removed and planted outdoors at once without drying. Some after-ripening will take place in the fall and some early in the spring, and at least a fair germination should result the first year. Some will doubtless lie dormant one year but many of these should germinate the second spring.

The plan followed by the author and one that will give a very high germination is that of mixing the freshly extracted seed with moist sand and placing the mixture in flower-pots in a cool storage. The extracting is done just after winter sets in and the temperature of the storage during the storage period is slightly below 40° F. The sand is kept moist during the storage period. About three months later the seeds are separated from the sand and sown in boxes in a greenhouse. The seeds are given a treatment with Semesan just before being sown and in the sowing they are distributed over the surface of the soil in boxes. A covering of pure sand to the depth of three-fourths of an inch is used. These seedlings are grown indoors until the end of May and are then grown outdoors in these boxes until the end of the season. At that time they are taken from the boxes and are heeled-in for planting in the nursery row the following spring.

Nursery Stock

Plants obtained from a nurseryman should be young, well-rooted, of good size for their age and on Siberian crab stocks. Strong one-year-old plants, one year from the bud, are desirable. Well-rooted plants, and plants that have made good growth during the first year following that of budding, will become established more quickly and will usually make better trees than those with poor root systems and weak shoots.

The Soil and its Preparation

A well-drained medium loam containing an abundance of humus is desirable for this fruit. Heavier soils and lighter soils than that recommended may be used if necessary as this fruit can adapt itself to a variety of soils. Good drainage is very important and areas that become flooded at any time during the year should be avoided.

The land should be well prepared before the planting is to be done. Summer-fallowing is good preparation and the area should have this treatment for one year at least. If the area has been in sod, summer-fallowing for two years may be desirable. A heavy application of well-rotted manure ploughed in before summer-fallowing is begun will improve the general condition of the soil greatly.

In the spring in which the planting is to be done, the soil should be cultivated as soon as the surface has become dry. Any irregularities in this surface left the previous autumn should be removed and the surface soil reduced to a finely divided condition.

Shelter

For the apple and crab-apple, shelter is very necessary. Even some of the crab-apples recommended may be killed back considerably during the winter when a reasonable amount of shelter is not provided. Where an effective shelter is present, on the other hand, the trees should suffer no killing and should fruit well. Trees of the Siberian crab will flower and fruit without protection, but they too will do better in the presence of shelter than in its absence. The subject of shelter for the fruit plantation is discussed in Chapter IV.

Planting

Trees of the apple should be set twenty feet apart each way. On a small area, where crowding frequently becomes necessary, closer planting may be permitted but the trees cannot be expected to make the best possible showing under these conditions. In no case should the trees be planted closer than twenty-five feet from a well-established shelter-belt. This distance might well be increased to thirty feet in many cases.

The planting should be done as early in the spring as possible. If it is possible to arrange to do the planting in April, it should be done at this time as April planting has been found more satisfactory than May planting. Fall-planting is not dependable in this climate. Full directions for planting are given in Chapter III and it is suggested that the reader consult this chapter for information on the subject.

Treatment after Planting

All fruit trees to be grown in this climate should be headed low and trained to the bush form. Trees in the bush form suffer less from winds than do those in the tree form and often survive the winter where trees grown with long trunks suffer seriously from winter injury. Immediately after being planted the tree should be cut back severely. Under Saskatchewan conditions, it is advisable to cut down the top to within six to eight inches of the ground and to leave only a stub not more than six to eight inches high. This cut should be made on the slant to permit the rapid escape of water falling on the cut surface. The wound made in giving the plants this heavy pruning should be covered with grafting-wax or melted para-wax without delay to prevent the drying-out of the tissue near the wound and to enable healing to take place rapidly. From this stub, branches will arise and these branches will form the framework of the top of the tree.

Newly planted trees before and after cutting back are shown at A, B and C in Fig. 23. The type of tree shown at A is that frequently sent out by nurserymen. That at B is the more desirable for most purposes. Both should be cut back as shown at C. The same plant at the end of the first season is shown at D.

To one unfamiliar with the process of heading trees low, this treatment may appear severe. Frequently large trees with long trunks and with branches originating three or four

feet from the crowns are sent out by nurserymen and to cut back such trees to within six inches of the ground, one requires considerable courage. But the removal of such a large portion of its trunk does much to restore the balance between root and shoot, upset by the destruction of a large part of the root system during the transplanting, and induces the formation of a head near the ground. Treated in this way, the trees will become established quickly and will produce tops that will have marked resistance to strong winds and to low temperatures.

Pruning

The following spring before growth begins, the branches produced on the stub the previous year should be thinned out and about five of the strongest allowed to remain. These should be distributed around the stub and one should be neither above nor below its neighbour. Each branch left should be cut back to one-third its former length or less. A plant thus pruned and with the following season's growth is shown at E in Fig. 23.

Pruning in the second spring following that of planting usually consists in cutting back the laterals about one-half their length. If little growth has been made and these laterals are not more than one foot in length this cutting back need not be so severe.

The additional pruning necessary will consist in the thinning of the smaller branches and in the removal of dead and injured wood. Where the branches become too numerous and the central portion of the tree becomes excessively shaded some thinning should be done. The thinning should be done with a view to opening the centre of the tree and to permitting more sunlight to reach that portion. Moderation in this type of pruning is desirable, however. Branches that show killing-back should be removed a short distance below the base of the portion showing visible injury and broken branches should be cut back to sound wood. Pruning may be necessary in the control of Fire-blight and directions for this are given in the section dealing with diseases of the apple.

The pruning required should be done at the proper times. That necessary in the training of trees, such as the thinning of branches and the cutting-back of sound branches, should be done in the spring before growth begins. The removal of portions that have been killed during the winter must be delayed until after leafing-out has occurred but it should not

be delayed longer than is necessary. Broken branches may be removed at any time during the growing season.

Cuts should be made at a point close to a bud or to a branch where possible. The wound should be as near the line of sap movement as possible. Wounds made in such places heal more quickly than do those where an unnecessary extension of the branch has been left and organisms of decay are less likely to weaken the plant in the former case than in the latter. All large wounds should be coated at once with either grafting-wax or melted parawax.

The best tools for such pruning are a fine-tooth saw and a

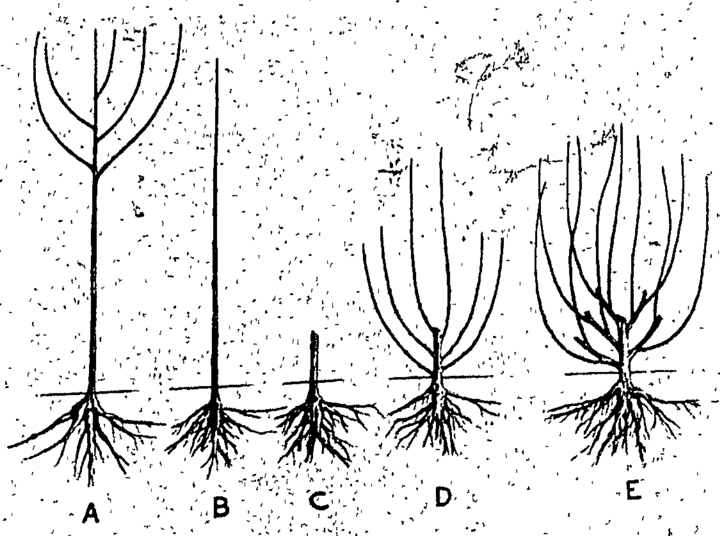

FIG. 23.—THE CORRECT METHOD OF PRUNING YOUNG APPLE TREES

pair of small hand shears. The shears are very satisfactory for cutting branches of very small diameter and the saw may be used effectively on the larger branches.

TILLAGE

Clean cultivation throughout the season in the apple plantation should be practised. Weeds should be kept down and the surface of the soil stirred occasionally to conserve moisture and to promote aeration. The use of a straw mulch during the early part of the summer is beneficial and might be employed where practicable.

HARVESTING THE FRUIT

Except in special cases the fruit of the apple should not be harvested until the seeds have become dark brown. When the seeds have reached this stage the fruit has reached maturity and harvesting should not be delayed long. Fruits of some varieties will remain in good condition on the tree for considerable time after reaching maturity and will permit a delay in harvesting but in some varieties even a short delay will result in marked deterioration in the fruit. The development of mealiness in the flesh is frequently a prominent characteristic in fruit that has thus suffered. Harvesting may take place before the seeds have fully darkened but early harvesting is usually at the expense of quality. Where the fruit is to be used in the making of jelly, however, harvesting prematurely is desirable.

Colour of skin is not necessarily an index of maturity. An apple that is well coloured may or may not be mature. Fruits in the early stages of development are usually green but in some cases they develop considerable colour long before maturity is reached. This is particularly true in red varieties. Relationship between colour of fruit and stage of maturity is probably closer in yellow or in striped varieties than in those with more or less uniform red colouring.

Removal of the fruit may be accomplished either by pulling or through the use of shears. Either method is satisfactory provided the spurs remain unharmed. Since much of the fruit is borne on spurs and since these spurs frequently carry buds that will give rise to flowers the following year, it is important that the fruit be removed without injury to these parts. In certain varieties the stems of the fruits are not easily separated from the spurs, particularly if the fruit is not fully mature and in such cases considerable damage to the plant may be done when pulling is practised. The use of shears usually lengthens the operation of harvesting the fruit but it minimizes the injury to the plant. Where the amount of fruit to be harvested is not large and where pulling results in damage to the spurs, shears should be employed. Ordinary scissors of fair size are very satisfactory and are more easily manipulated among the branches than larger shears.

WINTER PROTECTION

Special winter protection, beyond shelter from winds and that necessary to prevent rabbit injury, is seldom given to

apple trees. While beneficial to young trees in some measure at least a covering of straw and burlap is difficult to apply and it has some objections. Other special measures are not practicable and the grower should be content with a good shelter-belt and trees of the varieties that can be grown in the shelter of this belt without additional protection.

Pests

Seldom are insect pests found on the apple in the prairie provinces in sufficient numbers to necessitate treatment. In

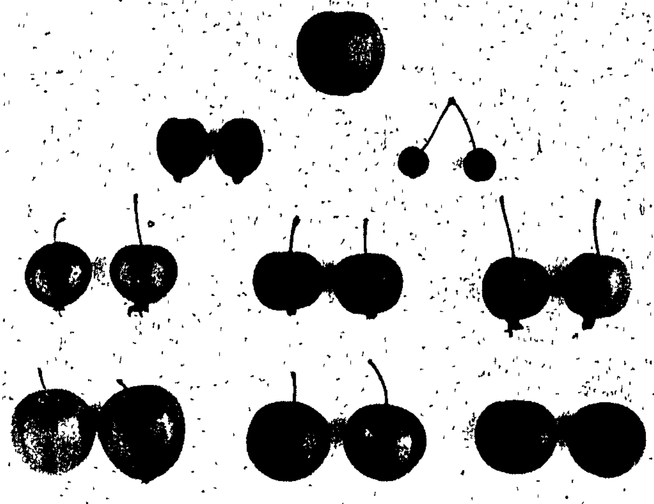

Fig. 24.—Different Varieties of Crab-apples

Trail
Alexis Siberian
Columbia Seedling Adam Robin
Lyman Jewel × Rideau

certain districts, one of the tent-caterpillars may be present in large numbers and treatment may be necessary. Occasionally canker-worms attack apple trees and do considerable damage. In both cases the leaves are eaten and injury is done early in the growing season. Either spraying or dusting with a standard food poison will effect control. Lead arsenate is the most desirable insecticide for use in these cases but either calcium arsenate or Paris Green may be employed. For dust-

ing these should be mixed with common flour in the proportion of one of the arsenical to twenty or twenty-five parts of flour.

Rabbits.—While not ordinarily classed as a pest, rabbits are enemies of fruit plants. They are very fond of young trees of the apple, plum and cherry and may do much damage in a short time. In districts where this pest is abundant, fruit trees must be protected against them.

The most effective measure against rabbits is that of fencing the fruit plantation. A fence six feet in height and of a two-inch mesh or less is usually sufficient to protect the plants. This should be well supported by posts not more than ten to twelve feet apart and preferably by a strand of No. 9 wire strung on top of the posts. Banks of snow that form near the fence and that might permit rabbits to gain entrance to the plantation should be broken down when necessary.

Various agents that are applied to the bark of trees have been tried as repellents against rabbits. Blood, lard, axle-grease, paint, waxes, resins, paper, asphalt, sulphonated oils and other agents have been used. Most of these have some virtue but much is required to repel a hungry rabbit. Some of these agents are harmful to the plants and cannot be used safely.

A very promising repellent is a combination of ordinary resin and linseed oil. This has been used in places and has given excellent protection. Five parts of resin are used to one part of linseed oil. The resin is heated over a slow fire, preferably out of doors, and when the resin has melted, the linseed oil is added. The material should be thoroughly stirred in order that a uniform mixture may result. This mixture is applied warm with a brush and only a thin coating should be used. All surfaces to be protected must be coated. One coating should last the whole winter.

Diseases

Fire-blight (*caused by* Bacillus amylovorus).—In the spring of 1933 the author wrote concerning this disease as follows: "Fortunately Saskatchewan apple trees have remained remarkably free from disease. At the present time, the only disease that need be mentioned is Fire-blight which occurs in Manitoba and which has not, to the knowledge of the author, made its appearance in Saskatchewan. In view of the fact that nursery stock is being imported to this province from Manitoba this disease is certain to come sooner or later and

all growers of the apple should be able to recognize it when it makes its appearance." During the summer of 1933 Fire-blight appeared in Saskatchewan and it came with a vengeance. Conditions were evidently favourable for its development and it reached epidemic proportions that year. Serious damage was done in many plantations and by the end of the growing season trees of certain varieties were killed back almost to the bases of their large branches. Since then it has spread and has taken an annual toll. There are, however, apple plantations in the West, particularly in Saskatchewan and Alberta, that have yet to experience this disease but sooner or later that experience will come.

This disease is caused by a definite organism as stated above and may attack any part of the tree above-ground. Much of the infection takes place through the flowers and insects are responsible in no small measure for its spread. It is most easily recognized on the twigs, where the blighted portions appear as though they had been scorched by fire. At first, wilting of the twigs affected occurs and, later, the foliage on these becomes dry and shrivelled. The bark shrinks and the diameter of the affected twig or branch is lessened. On the larger limbs, cankers appear and a gummy substance is found oozing from openings in these. The disease works down the twigs and branches, killing the affected parts as it goes and, if permitted to continue, it may kill the tree.

Control of this disease is effected easily through the use of resistant varieties. Varieties differ greatly with respect to their resistance to this disease, some being wholly resistant and others with apparently no resistance. The varieties recommended in this chapter have shown either very little or no susceptibility to the disease and only varieties with such resistance should be planted.

Where varieties susceptible to this disease are being grown, the removal of the blighted portions is the only known practicable remedy. If the variety is very susceptible, as in the cases of Transcendent, Charles and Jewel, and where the disease has made much progress, the removal and the destruction of the tree are recommended. Where control without destruction of the plant is to be attempted the diseased parts should be removed as soon as possible after discovery. Indication of the progress of the disease is given by the burning of the foliage and by the shrinking of the bark on the parts affected, and removal of the diseased portion is usually assured when the cut is made six inches below what is considered the beginning of sound tissue. The cut should

be made with sharp shears or with a sharp fine-toothed saw, depending upon the size of the branch being removed, and the wound treated without delay. The portion of the branch removed should be burned at once to prevent the further spread of the disease.

Treatment for the wound consists in wetting the cut surface with a solution of corrosive sublimate in water, one part of the chemical to one thousand parts of water, and then covering it with melted parawax or some form of grafting-wax. This sterilizes the surface and provides a protective coat for the tissues concerned.

The cutting surface of the pruning-tool too should be wet with the solution of corrosive sublimate in water referred to in the paragraph above after each cut is made. This destroys any disease organisms on the cutting surface and prevents the possible infection of disease-free tissues when the next cut is being made.

Cytospora Blight.—While usually regarded as saprophytes (those living on decaying organic matter) or very weak parasites, the Cytosporas appear to be responsible for injury to plants in certain cases. At least one form is frequently found on the apple, and there is some evidence to show that the fungus brings about an early death of the part concerned. In trees that are regarded fully hardy a branch may be found killed back severely, and an examination of the lifeless part will reveal numerous pimple-like bodies distributed over the surface of the bark. These are the fruiting bodies of the fungus, and from each one emerge thousands of spores that are capable of infecting suitable tissues. It is not unlikely that such branches suffer injury from low temperatures previous to attack by the fungus, but it is very probable that the fungus brings about the death of the part prematurely.

Treatment consists in the removal of the branches at a point well below the base of the injury and in the dressing of the wound as recommended for Fire-blight. The branches removed should be destroyed without delay. Good cultural practices that tend to keep the trees in vigorous condition should do much toward reducing the amount of injury that is probably caused by this fungus.

Black-heart, Sun-scald and other forms of injury associated with low temperature are discussed on pages 257-261.

CHAPTER VI

THE PLUM

No fruit garden is complete without at least a few trees of the plum. For many centuries this fruit has been prized as an article of diet and its value as such is appreciated more now than at any previous time. The plum completes an important link in the chain of fresh fruits and both in the fresh condition and preserved it offers a supply of palatable and healthful food. While plums obtained on the market usually meet the demands of the consumer, a home-grown supply not only does this without cash outlay but stimulates consumption of a fruit that is of great value in the diet.

Like certain other fruits the plum should be found in every prairie fruit garden. It is one of the first fruits that the beginner in fruit growing in prairie regions should attempt to grow. It is true that trees of nearly all the varieties grown commercially in special fruit-growing districts are tender under prairie conditions, but those of certain varieties that have been derived from native species are hardy and produce fruit that is pleasant to the taste and that has a high culinary value.

BOTANY

The plums belong to genus *Prunus*, which is the ancient Latin name of the plum. The plants are woody perennials, upright in habit and in some cases have thorny branches. The flowers are borne either singly or in small clusters which appear either before or with the leaves. The sepals and petals are each five in number, the stamens numerous and the pistil single. The fruit is typically a drupe, varying in size and shape and has a distinct suture. The pit is distinctly flattened.

Introduced Species.—While upwards of two hundred and fifty species of the plum are known, only a few of these are important as sources of fruit in America. The most important introduced species are the Common Garden Plum (*Prunus domestica*) and the Japanese Plum (*Prunus salicina*). The former is a native of Europe and western Asia and the latter a native of China. Varieties of *P. domestica* are grown extensively in the milder parts of Canada and the United States

but they lack the hardiness required for the colder parts of these countries. Plants of varieties of *P. salicina* also are grown in these milder sections and as a class they are slightly less hardy than those of the former species. *Prunus insititia*, another imported species and one that is native to Europe and western Asia, is of some importance and the best-known form of it is found in the damson plums.

Native Species.—Important species native to America are the Hortulana Plum (*Prunus hortulana*), Chickshaw Plum (*Prunus angustifolia*), Wild Goose Plum (*Prunus munsoniana*), American Plum (*Prunus americana*) and the Canada Plum (*Prunus nigra*). The first three species in the native group mentioned are tender in the prairie provinces of Canada and in parts of United States but are grown to some extent in the milder parts. The last two species are found growing as far north as Manitoba and they have given varieties that have proved to be extremely hardy. Of the two, *P. nigra* is the hardier and it appears to be more drouth resistant and better adapted to prairie conditions than *P. americana*. The leaves of *P. americana* have sharply serrated margins and the fruits have thick, tough skins and tend to ripen late. Leaves of *P. nigra* have margins with teeth that are usually rounded and the fruits have thin skins and tend to ripen early. The leaves of the latter two species are dull in contrast with those of *P. salicina* and most of its hybrids which are glossy. The flowers of *P. americana* are white while those of *P. nigra* are distinctly pinkish.

Development

Prunus domestica and *P. insititia* have been cultivated for over two thousand years. The latter was probably cultivated at an earlier date than the former. According to records the fruit of these in early times was much prized and was considered an important food. From the year 1300 on plums increased rapidly in popularity in Europe and the seventeenth century was a period of very marked development in this fruit. These species were introduced to America by French settlers in the early part of the eighteenth century. Plants of these were found to thrive on this side of the Atlantic and both species soon occupied an important place in plum plantations in America. Varieties of these forms increased as time went on and the few that were introduced from Europe increased during the two hundred years that followed to over one thousand named varieties, all of which have been grown

in American orchards. *Prunus salicina* has been cultivated in China since ancient times. From China it spread to Japan and other near-by countries. It was introduced to America from Japan in 1870. About one hundred varieties of this species are being grown in America at the present time.

Domestication of Native Plum.—The domestication of species native to America began about the middle of the

FIG. 25.—A YOUNG TREE OF ASSINIBOINE PLUM HEAVILY LADEN WITH FRUIT

nineteenth century. Even though wild plums had been admired as early as the time of the visits of Jacques Cartier, no early attempt to cultivate these species is on record. The first native plum to be introduced was Miner, a variety of *P. hortulana,* which appeared probably between 1820 and 1825. For some years after its introduction the plum was grown under several names and it was not until later that it was designated Miner. The second important variety of a

native species was Wild Goose which was obtained from *P. munsoniana* in 1850. Following these closely were the introductions of Wolf, Rollingstone, De Soto, Wyant and others which were varieties of *P. americana*. *Prunus nigra* was later in being domesticated and one of the first-named varieties of this species was Cheney, which appeared in 1887. Aitkin followed in 1896. A few important varieties of this species have appeared since 1900. Assiniboine, Winnipeg, Mammoth and Olson are among those of more recent introduction. Several hundred varieties of these native species are now being grown to a lesser or greater extent. Most of those grown in the very northerly sections belong to the last two species mentioned.

Development in the native plums was retarded by the popularity of imported species and the ability of these to thrive in the American climate. Varieties of *P. domestica* proved superior to the native plums and it was found that these could be grown successfully over a very wide range. With the introduction of *P. salicina* the difficulties experienced in the growing of good plums in the Middle West were met and this reduced the incentive to develop species native to that region. The Japanese plum too was found to thrive over a wide range and these two species supplied the needs in plums in most of the plum-growing sections of America.

Improvement by Hybridization.—The imported species proved too tender for northern districts, however. While producing fruit of very fair quality native plums were found inferior to those imported and a demand for better hardy plums was created. To meet this demand workers in this field resorted to hybridization. It was soon found that varieties of *P. domestica* would not hybridize readily with northern species. Varieties of the Japanese plum, on the other hand, hybridized readily with the native plums and improvement was sought through this avenue. *Prunus simonii* (Apricot Plum) was found compatible with these species and it too was used as a parent in breeding work. Numerous varieties of hybrid origin have been introduced and all these show marked improvement over varieties of the native species. Loss in hardiness has been experienced in nearly every case, however, and in certain varieties this has been very marked. In a few cases the loss has not been sufficient to prevent the growing of plums of hybrid origin in the Far North. The Japanese plum was found to hybridize readily with the native Bessey Cherry (*Prunus besseyi*) and a few hybrids thus obtained are frequently classed and grown as plums.

Classes

Most of the plums grown in the Far North belong to one of two native species, namely *P. nigra* and *P. americana*. The former species has made a much greater contribution to varieties than the latter. The varieties derived from these two species will be referred to as "American" plums.

Another class of plums of importance in this region are hybrids between native species and the Japanese Plum (*Prunus salicina*). The trees of the hybrids as a class are considerably less hardy than those of the native species but the fruit is superior in quality and in size in most cases. Considerable variation, both in hardiness of plant and in quality of fruit, is found in this class. These varieties will be referred to as "hybrid" plums.

Varieties

American Plums. *Assiniboine.*—This is a seedling of *P. nigra* and was grown by Professor N. E. Hansen from seed produced near Stonewall, Manitoba. Introduction took place in 1908. It is one of the hardiest and earliest maturing named varieties worthy of culture. The tree is very hardy and is very productive. The fruit is large with a moderately thin skin and with yellow flesh. The general quality of the fruit is good for a plum of this class. It is desirable for use both in the raw condition and preserved.

Winnipeg.—This too is a seedling of *P. nigra*. It is a companion variety to Assiniboine and these two varieties were obtained from the same lot of seed. Winnipeg is similar to Assiniboine, the fruit being of good size, with a thin, blushed skin and with yellow flesh, but its quality is slightly inferior to that of the latter. Its season of ripening is similar to that of Assiniboine. It is a desirable plum and should be used to supply variety where plums possessing hardiness in the extreme are required and where earliness is an important factor. Introduction took place in 1908.

Mammoth.—The tree of this variety is hardy at Saskatoon and is moderately productive. The fruit is large, red when ripe and with yellow flesh. The skin is thin and tender and does not toughen on being cooked. This is a hardy plum of outstanding merit. It is a seedling of Cheney and was grown and introduced by the late A. P. Stevenson, founder of Pine Grove Nursery (now Stevenson Bros.), Morden, Manitoba. It matures about the same time as Assiniboine.

Olson.—This variety also is a seedling of *P. nigra* and was grown and introduced by W. J. Boughen, Valley River, Manitoba. The tree is quite hardy at Saskatoon and possesses an abundance of vigour. The fruit is of medium size, is of exceptionally good colour, the flesh being deep yellow and the skin dark crimson, and the quality is almost equal to that of Cheney. It matures about ten days earlier than Cheney, however, but a few days later than Assiniboine. Olson is a good hardy plum.

Cheney.—This is a chance seedling of *P. nigra* and is a very desirable hardy plum. The tree is vigorous and very productive. The fruit is dark red in colour, has deep-yellow flesh and is of very good quality for this class of fruit. This is especially good for preserving. It matures about two weeks later than Assiniboine and Mammoth. This variety is not recommended for the most northerly settled parts on account of its late ripening, but is fairly dependable as far north as Saskatoon. The fruit is sensitive to frost and the first killing frost may result in the browning of the flesh of any fruits that are on the tree at the time. This is one of the oldest varieties of this class and was introduced in 1888 by the discoverer, E. Markle, La Crosse, Wisconsin.

Aitkin.—This variety has not become popular but it deserves a place among hardy plums. The fruit is of good size with red skin and yellow flesh and is of very fair quality. The fruit does not measure up to that of Assiniboine but it usually matures a few days earlier. It was a chance seedling found growing wild in Aitkin County, Minnesota, by D. C. Hazelton, and was introduced in 1896 by the Jewell Nursery Company of Lake City, Minnesota.

McRobert.—This is a new variety but it appears on a Manitoba list of recommended varieties of plums. It is a seedling of Assiniboine grown by J. C. McRobert, Gilbert Plains, Manitoba. The fruit is said to be similar to that of Assiniboine in appearance but superior to it in quality. The author is not familiar with this variety and information on its performance in Saskatchewan and Alberta is not available at the present time. Young plants of it have proved fully hardy in the fruit plantation of the University of Saskatchewan at Saskatoon.

Dandy.—This variety is a seedling of Assiniboine originated by W. J. Boughen, Valley River, Manitoba. The fruit is almost as large as that of Assiniboine and is considered to be of better quality. It is not widely grown and deserves a more prominent place among hardy plums for the North.

Valley River.—Being one of Mr Boughen's introductions this variety is well adapted to conditions in the Far North. The fruit is of medium size only but is of very fair quality. It is one of the earliest plums to mature and it should be used extensively in the most northerly sections.

C. K. C.—This is an introduction of Dr. Seager Wheeler, Rosthern, Saskatchewan. It is similar to Assiniboine, but the introducer considers it superior to that variety. It has not been tested widely but it is a very promising variety for the North.

HYBRID PLUMS.—Varieties in this class are recommended only where the best plums that can be grown are desired and where failure of the plants to bear much fruit in certain years will be accepted as a matter of course. Hardy varieties of the native species should be depended upon for the main crop of plums and these hybrid varieties used chiefly to add variety and interest to the fruit plantation.

Waneta.—The fruit of this variety is probably larger than that of any other variety in the group of plums that can be grown with success even in a small measure in northern districts. It is said to reach a diameter of two inches but this is somewhat greater than its usual size in Saskatchewan. It is a hybrid between the Apple, a variety of *P. salicina*, and Terry, a variety of *P. americana*. Its originator was Professor N. E. Hansen and it was introduced in 1913. The tree is not fully hardy in northern sections and the fruit is usually found only on the lower branches. The fruit is red when ripe, has a thin skin and is of good quality. Maturity is reached about one week to ten days later than in Cheney. The fruit will stand considerable frost without injury. This is one of the most satisfactory varieties in this group to grow, especially in southern districts.

Kahinta.—This is another of Professor Hansen's introductions. The parents are the same as those of Waneta. Introduction took place in 1912. The fruit is somewhat smaller than that of Waneta but is reported to be of good quality. It is not as widely grown as the former variety but is one that is worthy of a trial.

Pembina.—This variety is one of the best early plums. The fruit has good size, measuring well over an inch in diameter, is of good quality and matures in August at Saskatoon. It is delicious raw and makes very superior preserves. The tree has shown hardiness in a marked degree but the fruit-buds are somewhat tender and many fail to survive the winter in the northern parts of the Great Plains region. This variety

appears to present a problem in fertilization as the drop of immature fruit is heavy. This variety cannot be counted on to produce a heavy crop of fruit but it has a great appeal. The parents used in this case were *P. nigra* and Red June, a variety of *P. salicina*. It was originated by Professor Hansen and was introduced in 1917.

Ojibwa.—While having a record as a somewhat shy bearer Ojibwa is a hybrid variety of considerable merit. Shiro, a complex hybrid involving the Japanese plum and four other species, is the female parent and *P. nigra* the male parent. It too is one of Professor Hansen's originations and it was introduced in 1917. The tree appears to be vigorous and hardy. The fruit is of medium size only but has good quality. Maturity is reached in this variety two or three days later than in Assiniboine. As a variety of the hybrid group to be grown in the north it should be given a prominent place.

Cree.—This is another of Professor Hansen's introductions of 1917. It has *P. nigra* as its female parent and the Combination, a Japanese plum hybrid, as its male parent. The tree is hardy and moderately fruitful but the fruit is of very mediocre quality. An objectionable feature of the fruit is its tough skin. It matures about the same time as that of Assiniboine. It is well worthy of culture but it should be added to the list to be grown after most of the other hybrid varieties mentioned. The fruit might easily pass for fruit of a good form of a native species but the foliage has characteristics of the Japanese plum parent.

Tecumseh.—This is a promising variety that has been little grown in northern sections. A young tree planted in the spring of 1933 fruited for the first time in the University plantation in 1935. The winter of 1934–35 was severe but young trees of this variety showed only slight killing following this winter. The parents are Shiro and Surprise. It is one of Professor Hansen's originations and was introduced in 1918. The fruit is of good size with thin red skin and with flesh that is both aromatic and flavourful. Maturity is reached at Saskatoon about August 15th in a normal season. It is a high-class plum with considerable promise for the Far North.

Radisson.—While not as well known as it should be, this variety is succeeding in places in the prairie provinces. In one plantation in west-central Saskatchewan in which it has been tried it is succeeding in fair measure. It originated from a cross between unknown varieties of *P. salicina* and *P. americana* at the Minnesota Fruit Breeding Farm and was introduced in 1925. The tree usually suffers less from winter

killing than does Waneta and Underwood and, like the former, produces considerable fruit. The fruit is large with a red skin and with rich yellow flesh and the quality is described as "of the highest" by the originators and introducers. This variety will probably have an important place among hybrid plums in the prairie provinces when it becomes better known.

Hanska and Kaga.—These two varieties are very much alike and behave much in the same manner under cultivation. As parents they have *P. americana* on the female side and

Fig. 26.—A Fruiting Tree of Cree Plum

P. simonii on the male. These are Professor Hansen's originations and were introduced in 1908 and 1909 respectively. The trees are hardy and fairly fruitful. The fruit is of medium size, aromatic and very flavourful. The skin is tough and the flesh very firm. In both varieties the fruits mature a few days later than do those of Cheney. Their use is limited and they should be planted sparingly.

Tokata.—This is another variety with *P. simonii* as one parent. *Prunus simonii* is the female parent in this case, however, and De Soto, a variety of *P. americana*, is the male. The size and quality of the fruit in this variety are much above those in Hanska and Kaga and its rating as a variety

is high. Its season is a little earlier than that of Cheney. The plant lacks the hardiness of the other two varieties and can be depended upon to fruit only in the most favoured sections. At Saskatoon the entire crop of a tree has never exceeded one half-dozen fruits.

Winona.—Of the various varieties originated at the Minnesota Fruit Breeding Farm, St. Paul, Minnesota, and tested at the University of Saskatchewan, Winona has been by far the most fruitful. It is a hybrid between *P. salicina* and *P. americana* but the varieties are unknown. The tree has not proved to be fully hardy but it is sufficiently hardy to produce considerable fruit on the lower branches. The fruit is large and is of excellent quality. It is late in maturing, being ten days to two weeks later than that of Waneta, but it is uninjured by September frosts and matures well at Saskatoon. As high as one hundred and seventy-five pounds of fruit have been harvested in the University Plantation from four bushes of this variety.

Mina.—This is a seedling of Pembina produced at the Dominion Experimental Station, Morden, Manitoba. It has not been widely grown but the plant is reported to be hardy and the fruit superior in some respects to that of Pembina.

Elliott, Minnesota No. 56, Underwood, Loring Prize and Red Wing all have fruited at the University but the quantity produced has been small. The first three have been more fruitful than the last two but not more than fifteen pounds of fruit have been obtained from any one tree. Loring Prize and Red Wing have never produced more than a few fruits. From the standpoint of size and quality the fruits of all are good. Varieties possessing more hardiness and that are more fruitful, however, should be chosen in preference to these for culture in most parts of the prairie provinces of Canada at least.

Self-sterility

What is true in apples with respect to self-sterility is true in plums also. Trees of more than one variety, therefore, must be planted if the plants are to be fruitful in a satisfactory measure. Varieties in the American class are inter-fruitful with one another and with those in the hybrid class. Those in the hybrid class are inter-fruitful with varieties in the American class but are not inter-fruitful in all cases among themselves. Because of the cross-incompatibility existing in the hybrid group, the grower should always provide varieties of the American group to supply pollen for hybrid varieties.

Varieties in the hybrid group should not be depended upon as a source of pollen for American varieties. Where plums are to be grown at least three or four varieties in the American group should be represented in the plantation and as many others from either group added as are desired. Such a practice removes the possibility of failure due to possible incompatibilities and to differences in the dates of blooming and ensures a supply of suitable pollen for the crossing upon which fruiting depends.

FIG. 27.—A FRUITING BRANCH OF CREE PLUM AT CLOSE RANGE

PROPAGATION

Propagation of named varieties of the plum is by budding and grafting. Budding is the more common method used in the prairie provinces though some grafting is done. Seedlings of one of the native species of plums are used as stocks for the varieties mentioned.

Certain plants offered by nurserymen for fruiting purposes are merely seedlings of native plums. It is usually stated plainly that the plants in question are seedlings but in some cases this is not so. For instance, plants of "select native plums" may be offered, and in most cases at least they are merely seedlings of what was considered a better class of

native plums. No two of such plants offered would be alike, and the purchaser could not be certain that even one of a large lot would be equal to the mother plant with respect to the size and quality of fruit produced.

Propagation by Seeds.—Plum seeds must be after-ripened before germination will take place. The pits are separated from the flesh, washed clean and kept moist until planted or otherwise disposed of. Allowing the flesh to decay facilitates this separation and permits the rapid cleaning of the pits. To after-ripen, the pits require exposure to temperatures near 40° F. for a period of two to five months.

The usual plan followed in the handling of plum pits is that of planting them at a depth of one and one-half to two inches in moist soil outdoors. In this moist medium the pits are exposed naturally to temperatures near 40° F. for a period in the fall before winter sets in and for a period in the spring after the frost leaves the surface layer of soil. The fall exposure is made brief by the onset of winter and the spring exposure is cut short by the rising soil temperature during the latter part of April and early in May. In few seeds will the after-ripening be carried sufficiently far by the end of the spring after-ripening period to permit germination to take place. Not until second autumn and spring exposures to suitable temperatures have been made will germination take place in the majority of such seeds and a few may require third exposures. At least a fair stand is usually obtained the second year when favourable soil conditions have been provided. Sowing the pits in a frame made by placing rough boards on their edges is a better plan than that of sowing them in open rows.

A good germination in plums may be obtained the first year when longer exposures to after-ripening temperatures are provided. A simple and effective method is that of pitting. The freshly washed pits are mixed with clean, moist sand, and the mixture is placed in boxes. This sand must not be allowed to become dry. These boxes are kept in a cool basement until about one week before winter sets in. At this time the boxes are placed in a hole in the ground in a well-sheltered place and at a point approximately three feet below the soil surface. The boxes are covered at once with moist soil to the depth of a few inches. Water is used freely to moisten the contents of the boxes and the soil surrounding the boxes. Soon after the surface layer of soil has frozen to remain frozen about six inches of soil is added to that already in the pit and a week or two later, depending upon the weather,

the remaining space is filled with soil. Soil is banked slightly over the area, and this bank of soil is then covered with a few inches of leaves, straw or other litter for additional protection. The aim in this procedure is to keep the pits a few degrees above the freezing point for some time, and not to allow them to freeze until well on in the winter. In the spring the boxes are taken up and the pits separated from the soil and planted at once. This operation should not be delayed after the frost has left the contents of the boxes, as

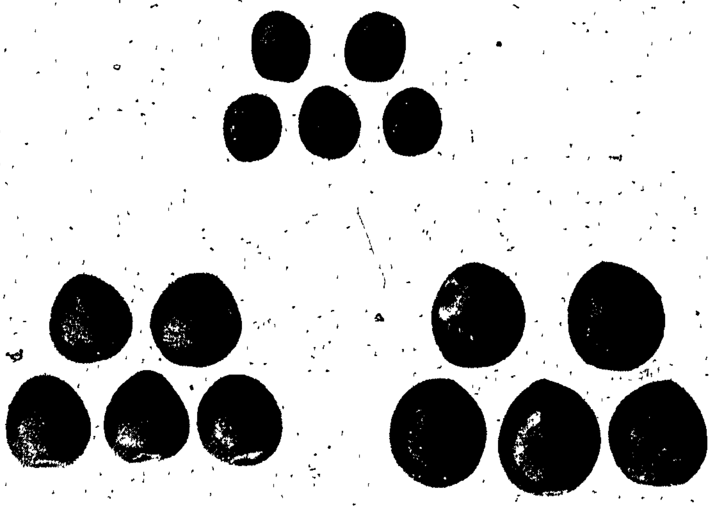

FIG. 28.—FRUITS OF WELL-KNOWN PLUMS

Underwood Cheney Waneta

germination takes place at low temperatures in after-ripened seeds and handling the pits without danger to the sprouts is impossible.

A suitable chamber in a cold storage might be used as a substitute for the hole in the ground suggested above. The pits are prepared for the cool chamber as for ground storage. A chamber with a temperature about 40° F. should be used. In this chamber they should be held for two months and in a chamber with a temperature just above the freezing point for two months. At the end of four months they should be transferred to a chamber with a temperature a few degrees

below the freezing point. Water is required at intervals of one or two weeks to keep the sand moist. Planting takes place at the normal time in the spring and should be done without delay after the removal of the pits from the cold storage.

Nursery Stock

Strong, vigorous, one-year-old budded plants with good root systems are desirable. It is important that these plants have as root stocks, seedlings of either *P. nigra* or *P. americana*.

Planting

The planting should be done early in the spring and all the usual precautions in the setting of plants should be taken. Spacings of fifteen to eighteen feet are ample for the varieties recommended for prairie planting.

Pruning and Training

Like those of the apple, plants of the plum should be grown in the bush form. One-year-old plants are usually mere whips without branches. Older plants supplied by nurserymen usually have a clean stem for a distance of three feet approximately, and the branches arise from the stem above this point. In both cases the plants should be cut back to within six to eight inches of the ground-level at the time of planting. It is well to delay the operation until just after the tree has been set. Such treatment induces branching close to the ground, and results in the formation of a bush type of plant. The cut should be made at an angle with the earth's surface and should be covered at once with wax. Grafting-wax is desirable for this purpose, but melted para-wax may be used if the former is not available.

One year later the branches produced the first season should be thinned if necessary and only five left to form the main framework of the tree. Those remaining should be the sturdiest of those produced and they should be as uniformly distributed as possible over the short section of stem left at planting time. These five branches should be cut back to one-third their length at this time, to induce further branching and the production of laterals.

Little further pruning is necessary. At the end of the second year—two years from the time of planting—the laterals produced during the second season should be cut back about half-

way to induce the formation of sub-laterals. Beyond this the only pruning necessary, in the majority of cases, is that required for the removal of dead and damaged branches. When the branches become unduly crowded the removal of a few of the least valuable is desirable. Those running toward the centre of the tree are less useful than others and these may either be thinned or removed.

The pruning should be done in the spring. While it may be done any time after the frost leaves the branches, the best time is just before growth begins. Branches broken during the growing season or during the autumn should be removed at once.

General Care

Clean cultivation and the keeping down of weeds and other plants that would compete with the trees for moisture are essential in the successful culture of plums on the prairies. While drouth-resistant and possessing ability to hold out well against the competition of other plants, trees of our native species of plums and their hybrids will do much better and will produce larger fruit under favourable conditions of moisture supply than under conditions where moisture is lacking. Clean cultivation should be practised throughout the growing season.

All shoots arising from the stocks should be removed as early as possible. Some may arise from the roots at points either close or distant from the plant. In some cases it is difficult to distinguish between shoots of the stock and shoots of the variety but a difference in leaf characters is usually discernible. Such shoots may be destroyed at any season and the operation should not be delayed unnecessarily.

Harvesting the Fruit.—In the plum as in other fruits harvesting should be delayed until the fruit reaches maturity. Harvested a week or ten days before reaching maturity fruit of the plum will mature but the quality of fruit ripened on the tree will be lacking in such cases. Firmness of flesh is usually a good guide in the harvesting of plum fruit and when the flesh yields readily to slight pressure, little is to be gained in delaying the harvesting operation.

Removal of the fruit in the plum is usually accomplished by pulling. The stem of the fruit in this case separates from the tree readily and pulling does not result in appreciable damage to the plant of the plum, as it frequently does to the plant of the crab-apple.

Diseases

Plum Pockets (*caused by* Exoascus pruni).—While not very common in the prairie provinces, this disease occurs in certain localities. When present, it frequently destroys a large percentage of the plum crop. It may be recognized soon after the fruit has set and fruits affected become very large, hollow and bladder-like and are without the customary pits. When first affected, fruit is yellowish in colour, but later it becomes whitish.

For the control of this disease, one spraying with water-soluble lime-sulphur, one pound to four gallons of water, should be effective. This must be given before the buds open and the most suitable time is shortly before opening occurs. Every part of the twigs, branches and trunk should be wet thoroughly with the spray. Since the organism causing the disease winters over as spores on or between the bud-scales, the spray must reach every bud if control is to be effected.

Black Knot (*caused by* Plowrightia morbosa).—Thus far this has not been a serious disease on cultivated plants in parts of the West but there is a possibility of its becoming such if proper precautionary measures are not used. It is found not only on the plum among cultivated plants, but also on the May Day Tree (*Prunus padus commutata*) and on some of the hybrids between the plum and Bessey cherry. It occurs on plants of the native chokecherry and there is evidence that the form attacking these will infect cultivated plants.

The disease is characterized by somewhat spindle-shaped, knotty swellings on the twigs. In some cases these completely surround the twig attacked, while in other cases they are confined chiefly to one side. At first the growths are small and the surface remains unbroken but these increase in size as time goes on, and the surface becomes cracked. Early in the season they are somewhat greenish in colour but later in the season they become black.

By removing and burning the knots twice a year, once in the autumn and once late in the spring soon after the new knots can be seen, one can do much toward eradicating this disease. This should be done not only on the cultivated plants being grown, but also on plants of the native chokecherry growing near by. The cut should be made a few inches below the knot. A spraying the same as that recommended for Plum Pockets should be given as a second measure for the control of this disease. One spraying is sufficient for both diseases, but thoroughness in making the application is essential to success in their control.

CHAPTER VII

THE CHERRY

BOTANY

THE cherries also are members of the genus *Prunus*. The plants are either shrubs or trees. The flowers open with or after the leaves and are borne either singly or in small clusters in the cultivated species. In the species not cultivated the flowers are borne in small clusters in some and in racemes in others. The sepals and petals number five each, the stamens many and the pistil is single. The fruit is a drupe, more or less globose in shape and is without the prominent suture found in the plum. The pit is usually slightly flattened but much less so than in the plum.

The most important species of cherry cultivated are the Sweet Cherry (*Prunus avium*) and the Sour Cherry (*Prunus cerasus*). Both are native to Europe. The latter species is the hardier of the two. The St. Lucie or Mahaleb Cherry (*Prunus mahaleb*), another European species, is of no importance as a source of fruit; but it is used extensively as a stock for both the sweet and sour cherries. An Asiatic species of some importance is the Nanking Cherry (*Prunus tomentosa*). The plant of this is a bush that possesses hardiness in a marked degree, and while small the fruit is of very fair quality. Native species of importance are the Bessey Cherry (*Prunus besseyi*), Chokecherry (*Prunus melanocarpa*) and the Pin Cherry (*Prunus pennsylvanica*). These three native species are very hardy and are found beyond the most northerly settlements in the prairie provinces of Canada. The sand cherry (*Prunus pumila*) and the Black Cherry (*Prunus serotina*), both of which are native to eastern Canada and to eastern United States, are not of any particular value as sources of fruit.

DEVELOPMENT

The first mention of the cherry found in literature was made by Theophrastus in his writings about 300 years B.C. While it was under cultivation in Greece at that time it is believed that it had been cultivated for centuries before Theophrastus' time, probably both in Greece and in regions

to the east of Greece. Evidence goes to show that both *P. avium* and *P. cerasus* were cultivated at that time. In the time of Christ, or soon after this, cultivated cherries were grown in the various parts of Europe where agriculture was practised. According to Pliny the cherry was taken to England from Rome before the middle of the first century. *Prunus avium* and *P. cerasus* were brought to America by French settlers in the sixteenth and seventeenth centuries. The first plantings of cherries made in America were of trees grown from seed brought from Europe. As early as 1608, however, trees were brought from France and in this year Champlain took cherry trees with him to Quebec in his second voyage to America. It is not known whether or not the trees brought in by Champlain were grown from seed, but it is known that vegetative propagation was not practised in America until some years later. In 1629 the Red Kentish was stated to be the only named cherry in New England, and by 1641 plants of this cherry were offered for sale by a Massachusetts nurseryman. Selections and importations were made in the years that followed, and in 1804 a Long Island nurseryman offered plants of over twenty named varieties of which Early Richmond, a prominent present-day variety, was one. From that time on varieties increased in number, and at the present time about three hundred varieties of *P. cerasus* and six hundred varieties of *P. avium* are grown. In addition to these about sixty-five varieties of Duke cherries are under cultivation.

Though believed to be hybrids between *P. cerasus* and *P. avium* the Duke cherries have the complement of chromosomes of the former and not the expected complement of normal hybrids between these two species. The name of the group comes from May Duke, one of the first-named varieties of this class.

Very hardy Sour Cherries.—Some progress has been made in obtaining hardy sour cherries for the north-west. Vladimir, Bessarabian and Shubianka, three varieties being offered by some nurserymen in the colder sections of America, belong to *P. cerasus*. The original plant of the first was the best of a number of seedlings obtained from seed imported from Orel in Central Russia by the late Professor J. L. Budd of Ames, Iowa, prior to 1882. The second variety is considered a variant of English Morello, and it was brought to America from Russia by Professor Budd about 1883. The third variety too was imported in 1883.

Improvement with Prunus besseyi.—*Prunus besseyi* has

played an important part in recent years in the development of hardy cherries for the Great Plains region of America. Through selection, improvement has been made and superior forms of this species are now obtainable. This species crosses readily with *P. salicina* (Japanese plum) and a number of resulting hybrids have been introduced. Some of these have been introduced as cherries and others as plums, but all are being treated as cherries in this volume. Some of the most common varieties in this group are Champa, Tom Thumb,

FIG. 29.—TOM THUMB CHERRY IN BLOOM

These are young plants in the plantation of Mr John Lloyd, Adanac, Saskatchewan.

Oka, Sapa and Opata. The pioneer work in the hybridization of these species was done by Professor N. E. Hansen of South Dakota Agricultural Experiment Station, Brookings, S.D., and all the varieties mentioned above are his introductions. The fruits of these are superior to that of *P. besseyi*, and while less hardy than those of this species in some cases the plants possess sufficient hardiness to be fruitful in favoured locations in most parts of the Great Plains region.

Improvement in Miscellaneous Cherries.—Possibilities for improvement exist in some of the miscellaneous cherries. Some improvement has already been made in *P. tomentosa*

and it is reported that plants have been obtained that are producing fruit over one-half inch in diameter. This cherry offers possibilities for the more severe climates and it is not unlikely that it will be, in a few years, a recommended fruit for the North-West. Seedlings of it have been grown in large numbers at the University of Saskatchewan but up to the present not one has been found that would be rated much more than half hardy, however. The pin cherry and the choke-cherry both offer possibilities for improvement but no attempt at their amelioration has been reported as yet. The pin cherry in particular should yield a fruit of considerable value for the North and efforts will doubtless be made in the near future to break the type and to obtain an increase in the size of the fruit. Efforts to hybridize it with *P. cerasus* and *P. besseyi* have been fruitless thus far but a species with which it will hybridize and through which marked improvement will be made possible will doubtless be found.

CLASSES

While several classes of the cherries are known, few of these are grown in the prairie provinces. Ordinary commercial cherries which are representatives of *P. avium* and *P. cerasus* cannot be grown successfully in this region excepting in a very small area in southern Manitoba. Those generally grown are either of *P. besseyi* or are derivatives of this species. Some of these have as one parent a derivative either of *P. salicina* or of *P. simonii* and consequently are of hybrid character. Some of these varieties of hybrid character are classed as cherries and others as plums, but since the plants are decidedly of the bush type and since the fruits of the so-called plums do not differ markedly in character from those of the cherries it appears advisable to class all as cherries. In certain sections two or three varieties of *P. cerasus* are grown with a fair degree of success. The chokecherry, pin cherry and Nanking cherry too are being cultivated to some extent. The cherries grown in the prairie provinces may be divided, therefore, into four classes, namely: Bessey Cherry (*Prunus besseyi*), hybrid cherries, sour cherries (*Prunus cerasus*), and miscellaneous cherries.

VARIETIES

BESSEY CHERRY. *Bessey.*—This is a native cherry and is widely distributed. The plant is a low-spreading hardy shrub

from two to three feet in height that usually fruits early and heavily. Plants frequently produce considerable fruit the third season from seed. The fruit varies in size from three-eighths of an inch to upwards of one-half inch in diameter. The normal colour of the skin of the ripe fruit is bluish-black and the flesh is usually red. Occasionally a plant that produces fruit with a green skin and green flesh is found. The fruit may be used in the making of preserves, but removing the pits, which adhere firmly to the flesh, is a tedious task. For jam-making and jelly-making the fruit of this cherry is very useful but the precaution of using fruit that is not too ripe, which is necessary in making jelly from chokecherry, is necessary in making jelly from Bessey cherry also. Improved strains of this cherry have appeared and some of these are vastly superior to the unimproved forms. Probably the greatest use to which this cherry has been put is that of breeding. It is used also as stocks for many named varieties of the cherry. Since they are grown from seed, plants of this cherry are cheap and a supply of useable fruit can be produced with very little cash outlay for plants.

Sioux.—This variety is a seedling of *P. besseyi*. The plant has the characteristics of its parents but its fruit is larger and of better quality than that of the usual run of Bessey cherry seedlings. It was introduced by Professor Hansen in 1902.

Champa.—This is a seedling of Sioux. In habit the plant is somewhat similar to that of the Bessey cherry but it reaches a greater diameter and a greater height. It is hardy, is very productive and fruits at an early age. The fruit is large for fruit of the Bessey cherry, is free-stone and is of good quality for a cherry of this type. It is a very superior form of *P. besseyi.* Introduction took place in 1912 and this too is Professor Hansen's production.

Brooks.—This is a seedling grown at the demonstration farm of the Canadian Pacific Railway, Brooks, Alberta. The fruit measures up to an inch in length or more and is said to be of good flavour. This variety has not been widely tested and cannot be recommended for general planting as yet.

Manmoor.—This variety was introduced by the Dominion Experimental Station, Morden, Manitoba, in 1929. The fruit is described as often measuring up to three-fourths of an inch in diameter and as being more reddish in colour when preserved than most other cherries of this type. It is of mild flavour and of very fair quality. This variety requires further testing before it can be recommended for general planting.

HYBRID CHERRIES. *Tom Thumb.*—Being a seedling of Ezaptan, which is a *P. besseyi* × *P. salicina* (variety Sultan) hybrid, this variety is a plum-cherry hybrid. The plant is low growing, is moderately hardy and is very productive. The fruit is large for a cherry and is considerably larger than that of Champa. It has bluish-black skin and dark red, juicy flesh. The plant is a very early bearer and usually begins fruiting the year after that of planting. This is a very satisfactory fruit for use both raw and preserved. It is one of the most dependable hardy cherries. Professor Hansen introduced this cherry in 1916.

Oka.—This variety is a seedling of Champa, and appearing in 1924 it is one of Professor Hansen's later introductions. It is one of the newer plum-cherry hybrids that is listed as a cherry. The plant is more upright and grows much taller than that of Tom Thumb but is somewhat less hardy. The fruit is much larger than the fruit of Tom Thumb and is of much better quality. The skin is dark purple in colour and the flesh red. This is a very desirable variety that should be represented in every well-sheltered prairie fruit plantation.

Opata.—This is from a cross between *P. besseyi* and *P. salicina* (variety Gold), and was introduced by Professor Hansen in 1908. This variety is probably better known than any other in this class. It is generally classed as a plum; however. The plant is not fully hardy even when grown in the bush form though nearly so. The upper branches frequently suffer some killing but the lower branches escape injury in most cases and fruit well. Plants usually begin fruiting the second or third year after that of planting. The fruit is of very large size for a cherry, averaging nearly one inch in diameter, is deep red in colour, is reasonably firm and has yellowish-green flesh. The quality is good for a fruit of this class and is excellent for use in the raw condition. For some reason it loses in quality when being preserved but the preserves are of fair quality and are very acceptable. It is a mid-season variety and the fruit ripens before heavy autumn frosts occur.

Sapa.—The parents of this variety are *P. besseyi* and *P. americana* (variety De Soto). Like Opata, Sapa is usually classed as a plum. The plant suffers from killing even more than does the plant of Opata but considerable fruit is produced on its lower branches. The fruit is about the size of that of Opata but has a bluish-black skin when ripe and dark red flesh. In quality the fruit of this variety surpasses that of Opata and is very good both in the raw and preserved forms. The fruit matures about mid-season and before heavy

autumn frosts come but it is uninjured by September frosts and will remain on the plant in good condition until October. This is a superior cherry and it is unfortunate that it should be lacking in hardiness. This variety should be tried, however, in favoured locations. It too is one of Professor Hansen's introductions of 1908.

Compass.—This is a hybrid between *P. besseyi* and *P. hortulana mineri* (variety Miner). The plant is upright in habit, is hardy and is moderately productive. The fruit is

FIG. 30.—CHAMPA CHERRY IN BLOOM.

This bush was planted two years previously and is only three years from the bud. The stake is three feet in height.

larger than that of the sand cherry but is smaller than that of Sapa and Opata. The skin of the mature fruit is red and the flesh yellowish-green. The quality of the fruit is not high though preserves made from it are very tasty. It is too late in maturing for northern sections but is found reasonably satisfactory in southern sections. This variety was originated in 1891 by H. Knudson, Springfield, Minnesota, and was introduced in 1897 by C. W. Sampson, Eureka, Minnesota.

Mordena.—This variety is a seedling of Compass that originated at the Dominion Experimental Station, Morden, Manitoba, and was introduced in 1930. The plant is a strong

grower and has an upright and spreading habit like that of the Compass parent. It is rated very hardy in Manitoba. The fruit is of good size, reaching a diameter of one inch or a little more at times, with dark-purple skin and deep-red flesh. The general quality of the fruit is good for a cherry of this class. Maturity is reached a few days earlier than in Compass. While its suitability to a wide range of conditions has not been determined as yet this variety will probably find a place in many fruit plantations in the three prairie provinces.

Zumbra.—This is a multiple hybrid with *P. avium* × *P. pennsylvanica* as one parent and *P. besseyi* as the other parent. It is an origination of the Minnesota Fruit Breeding Farm and was introduced in 1920. It is grown to considerable extent south of the international boundary but it is too late for many parts of the prairie provinces. The plant is small and bush-like and is moderately hardy. The fruit is of good size for the type, occasionally measuring up to one inch in diameter, with dark-reddish black and moderately tough skin and with greenish-yellow flesh. The quality is mediocre only.

Nicollet.—This variety is of similar parentage to that of Zumbra and was introduced in 1925. The plant is small and bush-like and the fruit is similar to that of the sour cherry. It is reported to be a promising variety but lack of information concerning its behaviour in the prairie sections of Canada prevents it from being included in the list of recommended fruits for this section at the present time.

St. Anthony.—The parents of St. Anthony are either Bessey cherry or a Bessey cherry hybrid and Satsuma plum, a variety of *P. salicina.* The plant is similar to that of Compass in type, being more upright than that of Zumbra. The fruit is of good size and resembling that of Sapa somewhat but with a purplish-red skin. The quality of the fruit is very fair but its season is too late for the northern parts of the prairie provinces at least. It is a production of the Minnesota Fruit Breeding Farm and was introduced in 1923.

Valley City, Ruby, Sanoba, Prolific and other new cherry hybrids are being offered to the public. All may prove valuable but until more is known concerning them the intending grower who wishes to plant only varieties that have survived the test of time should confine his list to those varieties that are recommended.

SOUR CHERRIES. *Vladimir.*—This is a variety introduced from Russia by the late Professor J. L. Budd, Ames, Iowa. Fruits of the original variety were fairly large but propaga-

tion has frequently been by seed and a loss in size has resulted. The fruit of Vladimir grown in western Canada is of medium size only, being usually not more than one-half inch in diameter with a dark-red skin. The flesh is dark red in colour, astringent, sour and of fair quality. Plants of this variety and its seedlings are very productive.

Bessarabian.—This is another variety introduced from Russia by Professor J. L. Budd. The fruit is of medium size and is larger than that of Vladimir seedlings. It is dark red

FIG. 31.—FRUITING BRANCHES OF OPATA CHERRY

This clustering of the fruit is characteristic of the variety.

in colour, sour and of fair quality. The plant is hardy for a sour cherry, is vigorous but is not a heavy bearer.

Shubianka.—This is a third variety introduced by Professor Budd. It is inferior to Vladimir and Bessarabian but some of its seedlings are reported to be a decided improvement over the original form.

MISCELLANEOUS CHERRIES.—Named varieties of the choke-cherry, pin cherry and Nanking cherry are not generally recognized as yet. At some future time improvement in these cherries will have been carried sufficiently far to warrant the recognition and propagation of special varieties. In the mean-

time the grower must confine his plantings of these fruits to seedlings of the best forms available.

SELF-STERILITY IN VARIETIES

Like most varieties of other tree fruits the named varieties of the cherries listed are, for all practical purposes, self-sterile. Plants of the Bessey cherry are inter-fertile because they are grown from seed and no two seedlings are identical. The varieties in the Bessey cherry and hybrid-cherry groups are all inter-fertile with one another and pollen from the flowers of any one variety will result in the fertilization of flowers of any other variety when a proper transfer has been made. While two varieties from these groups planted together should be sufficient for fruitfulness, and are sufficient at most times, occasionally the plants of a variety fail to flower and when this happens with plants of only two varieties present no fruit is produced. The use of three varieties is safer than the use of two and where conditions will permit the use of four or more the extra varieties should be included.

The cherries in the third group are usually considered self-fruitful and while they frequently are they should be regarded as self-sterile. The varieties mentioned are inter-fertile, however. Vladimir and Bessarabian are frequently grown from seed and in such a case no two plants are identical. When planted together seedlings of one variety should be fruitful.

Since those in the fourth group are kinds rather than varieties plants of one kind are not inter-fertile with plants of another. Seedlings of all three kinds are self-sterile but those of any one kind are inter-fertile with one another.

PROPAGATION

The named varieties of the cherry listed are normally propagated by budding and grafting. The former method of propagation is more common than the latter. For the named varieties of Bessey cherries and Bessey cherry hybrids, with the exception of Compass, seedlings of the Bessey cherry are usually employed as stocks. For Compass, seedlings of one of the native plums are usually employed. Native plums are sometimes used as stocks for Opata. Seedlings of the sour cherry are used as stocks for Vladimir, Bessarabian and Shubianka where these are propagated by graftage. The

pin cherry and chokecherry are sometimes propagated by suckers that spring up around the parent plants.

The Bessey cherry, pin cherry, chokecherry and Nanking cherry are usually propagated by seed. Vladimir, Bessarabian and Shubianka are frequently propagated by seed also.

The treatment of pits of the cherries is similar to that for pits of the plums. Shrivelled seeds are frequently found inside the bony covering of the pit in certain cherries and the germination is poor in many cases.

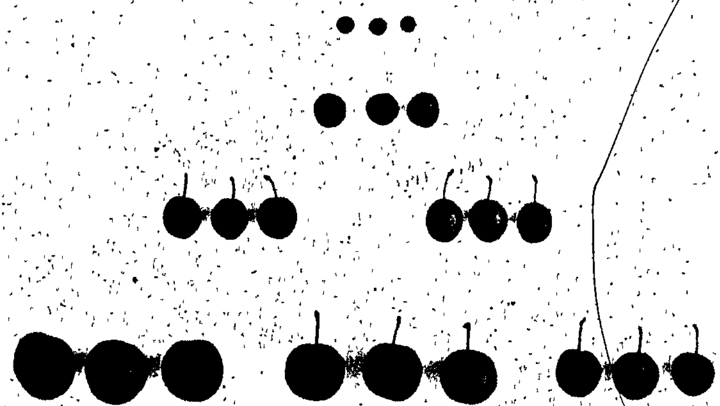

FIG. 32.—FORMS AND VARIETIES OF CHERRIES

Choke
Bessey
Champa
Compass
Opata
Oka
Tom Thumb

NURSERY STOCK

Budded stock is usually superior to grafted stock and one-year-old plants are preferable to those older. Vigorous plants with good root systems are desirable. Plants with the proper root stocks are essential. Two- or three-year-old seedlings are desirable where seedlings are to be planted.

PLANTING

As for most other fruits the planting, in the case of the cherry, should be done early in the spring. Reasonable care

must be exercised when the operation is being performed. A discussion of the principles of planting is given in Chapter III.

The spacings recommended for the cherries listed range from six to fifteen feet. For the smaller growing kinds, such as the common Bessey cherry, Sioux and Tom Thumb, six to eight foot spacings are ample. Plants of the varieties Champa, Oka, Sapa and of the Nanking cherry should be given ten foot spacings while those of Compass, Opata, Vladimir, Bessarabian, pin cherry and chokecherry should have spacings of twelve to fifteen feet.

Pruning and Training

Since cherries should be grown in the bush form in the prairie climate the plants should be cut back severely at planting time. Plants with single stems should be cut back immediately after being planted to within four to six inches of the ground level. This treatment induces branching near the ground surface and results in the type of plant desired.

In the spring of the second year the shoots produced the year before should be cut back about half-way to induce further branching. If these shoots are crowded some thinning should be done. In most cases five to seven well-distributed branches are sufficient.

Further pruning in the cases of the sour and miscellaneous cherries consists chiefly in cutting out any branches that have been injured or broken. If the bushes become so thick that sunlight is not admitted to the centre a few of the inside branches should be removed. This pruning also should be done early in the spring.

In the Bessey cherries and hybrid cherries more pruning than this is necessary if the plants are to continue fruiting well. There is a definite tendency in an unpruned bush of these cherries toward heavy production during the first two or three years of fruiting, and then a marked falling off in the production of fruit in later years. Most of the fruit in these varieties is produced on new shoots and the plants should be so pruned that abundance of new shoots are produced each year for bearing the fruit the year following. Only vigorous plants produce abundance of such wood and the vigour can be increased by pruning. Heavy pruning results in the production of an excessive number of shoots, and the pruning done must be moderate in amount. From one-third to one-half of the branches cut back about half-

way or more each spring should be sufficient pruning, under average conditions, to induce the production of the new growth required for consistently heavy bearing in plants of these cherries.

General Care

In addition to having the ground in which they are growing kept clean and free from other plants, cherries require little in the way of general care. In the cases of those with Bessey cherry stocks close watch should be kept for shoots from the parts below the ground. Bessey cherry stocks tend to sucker and when not removed in good time these suckers injure the portion of the plant consisting of the named variety and may choke it out eventually. No difficulty should be experienced in distinguishing between shoots of the Bessey cherry and those of the named varieties budded or grafted on this stock as the leaves of the former differ markedly from those of the latter. In the hardy sour cherries that are propagated by budding and grafting, and for which seedlings of these varieties are used as stocks, effort must be made not to allow any shoots originating below the ground level to remain as the differences between the stock and the named portion of the plant may not be appreciable in some cases at least.

Diseases

Coryneum Blight (*caused by* Coryneum Beijerinckii).—This disease is frequently prevalent in Bessey cherries and is sometimes found on hybrids of the Bessey cherry and plum. It attacks both the leaves and the fruits. The leaves attacked have numerous circular spots which are more or less brownish in colour with dark-red margins. Toward the end of the season the tissues affected may fall leaving holes in the leaves. Numerous spots may appear on the fruit. At first the areas affected are small and are reddish. These areas increase in size and the centre becomes light-coloured. Later the spots are brown and become more or less joined together.

Information on the control of this disease on Bessey cherry is not available. It is very probable, however, that the treatment that has been found satisfactory for the control of the same disease on peaches in parts of United States would be beneficial at least. Until further information on the subject is available the grower of Bessey cherries that is experiencing trouble from this disease is advised to use the measure that

has given good results in the peach. This treatment consists in spraying the plants with Bordeaux Mixture in the fall and in the spring. The fall application should be made early in October and the spring application just after the petals fall. Where the disease has been severe, a second spring application might be made two weeks after the first.

Powdery Mildew (caused by Podosphaera oxyacanthae).—This disease too is common in the Bessey cherry. The Bessey cherry hybrids are much less subject to it than are Bessey cherries. It attacks the leaves and the fruit and twigs to some extent. The affected parts become more or less covered with a whitish or greyish mouldy growth and fail to develop their normal size.

In the case of this disease too on Bessey cherry information is lacking. Dusting the plants with common sulphur as soon as the fungus makes its appearance should prevent the further development of the disease. Where sprayings with Bordeaux Mixture are given for the control of Coryneum Blight, mildew should not be troublesome.

CHAPTER VIII

THE STRAWBERRY

THE strawberry is one of the most popular fruits grown in Canada. It makes its appearance early in the season before other fresh temperate fruits are obtainable and at a time when fresh fruit is craved by everyone. Its juiciness, its mild acidity, its delightful flavour, and its attractive colour all demand for it a prominent place among both desserts and preserves.

Perhaps no other fruit has as great a climatic range as has the strawberry. It grows well in the warm climate of southern Florida and it has been found growing wild north of the Arctic Circle. In the most southerly part of its range, where the summer temperatures are very high, it fruits during the cool season and in the Far North, where it fruits during the summer months, its prostrate habit enables it to pass the winter under the protection offered by Nature's covering of snow.

At least a few plants of the strawberry should be found in every home garden. The plants can be grown with little effort and a small bed will supply ample fruit of this class for the table of the average family. Fresh strawberries and cream make a delightful dish and only those that have a home-grown supply of this fruit are able to appreciate fully its pleasing and its stimulating qualities.

BOTANY

The strawberry belongs to the genus *Fragaria*. Fragaria is derived from the latin word *fragran* meaning fragrance, alluding to the aroma of the fruit. The plant is a low-growing perennial with a very short thick stem that lies close to the ground. Long slender prostrate stems, known as runners, arise in the axils of the leaves and, at the ends of these, leaves and roots are produced resulting in new plants. Two sets of roots are produced by runner plants. Those produced first are short and stout. Long, slender and fibrous roots appear later. Each runner is normally two internodes in length. The first node fails to produce a new plant but in some cases it produces a branch runner. The new plant produced at the end of the

runner or at the second node in turn produces runners and well over one hundred plants may result in a season from a single mother plant. The connecting link between the parent plant and the new plant functions for a time but it eventually ceases to function and shrivels. Under certain conditions runners begin to appear early in the growing season and may be produced vigorously throughout the growing season. Under other conditions few are produced until after the fruiting season. The leaves are compound, consisting of three leaflets and these are toothed. The flowers, which are produced in clusters on leafless stalks, are normally either perfect or pistillate. In some cases flowers that are ordinarily perfect have non-functional pistils. The calyx and corolla each have five divisions but the former is reinforced by five sepal-like bracts. The stamens in a perfect flower are very short and are numerous. The pistils are numerous and are distributed over a conical receptacle. The fruit is known as an accessory and is usually globular or oblong conical in shape.

Only two species are believed to be concerned in cultivated varieties of this fruit. These are *Fragaria chiloensis* and *Fragaria virginiana*. *Fragaria chiloensis* is a native of the west coast of South America and a form found on the west coast of North America from California to Alaska is believed to be of the same species. *Fragaria virginiana* is native to America and is the form found wild in the prairie provinces of Canada. The fruit of the former species is of fair size and is firm while that of the latter species is small and lacks firmness. In both cases the fruit is very flavourful. Perfect and pistillate flowers are found in both species. Genetically these belong to the same group, each having twenty-eight chromosomes. They hybridize readily and the hybrids resulting are fertile.

Two European species that were thought at one time to have made contributions to the modern strawberry are *Fragaria vesca* and *Fragaria elatior*. The fruits of these are small and lack the flavour and aroma of *F. virginiana* and *F. chiloensis*. *Fragaria vesca* has only seven chromosomes and *F. elatior* twenty-one. These species will hybridize with *F. chiloensis* and *F. virginiana* but the hybrids are sterile.

Development

The strawberry is of relatively recent development. Evidence goes to show that it was cultivated in France as early as the fourteenth century. Varieties appeared toward the end

of the sixteenth century and in the early part of the seventeenth century, and in 1629 Parkinson made reference to six varieties that were in existence at that time. All of these were of the European species, *F. vesca.* In 1624 the American species, *F. virginiana,* was introduced to France. In 1629 it was taken from France to England, where it met with favour. This strawberry soon became a popular garden fruit. The Chilean strawberry, *F. chiloensis,* was introduced to France in 1712 and to England in 1727. The plants of the latter species taken to Europe produced only pistillate flowers and proved to be unfruitful when grown alone. When grown with plants of *F. virginiana* and *F. elatior,* however, they were fruitful. At this time most of the forms grown produced small fruit. About 1750 large-fruited strawberries appeared but these were slow in replacing the smaller form that had become well established. A variety appearing about this time was the Pine, which was derived from *F. chiloensis.*

Development in America.—Soon after the appearance of the Pine variety plants of some of the improved forms were taken to America. Not until near the end of the eighteenth century, however, did the Pine strawberry reach this continent. Strawberry plants were first offered for sale in America in 1771. Plants of four varieties were offered. These were Redwood, Large Hautboys, Chili and Wood. The first and second were of the European species, *F. vesca* and *F. elatior* respectively; the third of *F. chiloensis* and the last of *F. virginiana.* Additional varieties made their appearance in the years that followed and by 1834 nearly fifty varieties were under cultivation in America. Nearly all of these were offspring of *F. virginiana* and had originated in England and France. Varieties derived from *F. chiloensis* had been introduced from Europe, but their plants failed to adapt themselves to American conditions. In 1834 C. M. Hovey crossed varieties of *F. chiloensis* that had been introduced from Europe with Methven, a variety of *F. virginiana,* and in 1838 introduced a variety that bore his name. Hovey was the first high-class strawberry The introduction of this variety proved to be the starting point for the establishment of a greatly improved race of strawberries on this continent. Since then many new and better varieties have been originated and a long list of superior varieties is under cultivation at the present time.

Origin of Ever-bearing Varieties.—The ever-bearing strawberry is of recent origin. All varieties in this class have descended from Pan American, an autumn-bearing variety.

Pan American is said to be a bud-sport of Bismark and was introduced in 1898. Bismark is a summer-bearing variety with Bubach and Van Déman as parents.

CLASSES

Strawberries of two distinct classes are being grown at the present time. These classes are usually designated as "summer-bearing" or "June-bearing" and "ever-bearing". Plants of the summer-bearing class fruit in this climate during the last week in June and the first two or three weeks of July and have a relatively short fruiting period. During this period the plants direct their energies toward the production of fruit and a large amount of fruit is produced in a short time. After the fruiting period is over the plants send out runners freely and during the autumn form buds for the crop to be produced the following year. Plants of the ever-bearing class begin fruiting in this climate in July and continue fruiting until the first heavy frosts of autumn occur. Their fruiting period is long but at no picking is a large yield obtained. Owing to this long fruiting period, plants of the true ever-bearing type frequently produce few runners and in some cases fail to form a matted row. Some of the fruit-buds for the next year's crop are formed in the autumn, but some are not formed until the spring of the year in which the fruit is produced in this group of varieties.

Under average conditions summer-bearing varieties are preferable to ever-bearing varieties. Summer-bearing varieties produce their fruit when strawberries are in season and ever-bearing varieties produce their fruit over a period when many fruits are in season. Most people expect strawberries early in the summer and enjoy them more at this time than they do later. After the normal season for fresh strawberries is over, other fruits are in season, and at that time those fruits are usually preferable to the strawberry. Plants of the ever-bearing varieties seldom yield over a given period as much fruit as do plants of the summer-bearing varieties, and a plantation of considerable size would be required to meet the needs of the family at any one time where ever-bearing varieties were being grown. Fruit produced late in the summer and early in the autumn, when the hours of sunshine are diminishing rapidly and when the intensity of the light is decreasing, is inferior in quality and is not as delightful to the palate as fruit produced in the normal season. Moisture supply too is an important factor for consideration, and on

the Canadian prairies this is more favourable early in the summer than it is late in the summer and early in the autumn. June and July are usually the months of greatest precipitation and strawberries being developed and ripened during this period will be larger and of better quality than those produced during the months of drouth. Further, plants of ever-bearing varieties, as a group, are less hardy than plants of the summer-bearing varieties grown in the West and plants of the latter are frequently wintered easily when plants of the former suffer severely from winter killing.

Under special conditions the growing of ever-bearing varieties may be desirable. Where quantity is not an important factor and where the novelty of having fresh strawberries late in the season has an appeal, the growing of plants of an ever-bearing variety can be undertaken with assurance of a fair return in pleasure at least. Certain growers of ever-bearing strawberries in this climate do not attempt to winter over the plants and each spring import plants from a region where the plants of these varieties can be wintered without difficulty. Such a plan ensures a crop of fruit but it adds considerably to the cost of growing strawberries.

Differentiation in Buds

At a certain stage in the development of a bud, differentiation occurs. Until this time a bud is capable of giving rise either to flowers or to vegetative growth. The time comes when the destiny of the bud must be determined. Some of the buds begin to show flower primordia and the destiny of such a bud is in the production of fruit. Others show no flower primordia and their destiny is in the production of runners and crown divisions.

Buds may be produced throughout the growing season. In general buds formed when the days are very long give rise chiefly to runners. Those produced when the days are shorter give rise chiefly to crown divisions and many of those produced when the days are shorter still give rise to flowers.

Flower-buds are formed in the autumn in summer-bearing varieties and in both autumn and spring in ever-bearing varieties. In very northern latitudes these buds are formed chiefly during September in the former class of varieties. In the latter class of varieties the fruit produced early in the season is from fruit buds formed in September and that produced later is from fruit buds formed the following spring.

Types of Flowers

Two fundamental types of flowers are found in the strawberry. One type is perfect, where both the male organs and the female organs are present and in a normal condition. The other type is imperfect and in this the pistils are normal but the stamens are either rudimentary or absent. The former is often referred to as bisexual and the latter as pistillate. Normally one type of flower is produced by a variety and varieties are designated as "perfect" or "imperfect" depending upon the type of flower produced. Plants producing perfect flowers are usually productive whether planted alone or not and the fruit is normal in shape but plants producing imperfect flowers are either unproductive or produce small and mis-shapen fruit when planted alone.

An imperfect variety should never be planted alone. When such a variety is to be grown, plants too of a variety producing perfect flowers should be grown. Rows of a perfect-flowered variety alternating with rows of a variety producing imperfect flowers is very satisfactory under these conditions.

Certain varieties that usually produce perfect flowers may become partially pistillate at times. While little is definitely known concerning this peculiarity it is believed to be the result of unfavourable environmental conditions obtaining during a critical period in the autumn.

Plants of a perfect-flowered variety frequently produce sterile flowers. Sterility in this case is the result of the pistils failing to develop. Such flowers may be found on all varieties and in some cases they may exceed 50 per cent of the flowers produced. Flowers from late-formed buds and those of late trusses usually show a higher percentage of sterility than do others. This tendency is traceable to the dioeciousness in the ancestry of present-day varieties and is believed to be favoured by some unknown condition obtaining during the period of bud formation.

Perfect-flowered varieties are much more numerous than those with imperfect flowers. Very few of the important present-day varieties fall in the latter class and nearly all those that have been grown in northern sections produce perfect or bisexual flowers.

Varieties

A long list of named varieties of the strawberry appears in fruit lists but only a few of these varieties can be recom-

mended for sections in the Far North at the present time. No variety can be strongly recommended. Further experimentation may reveal the suitability of certain other varieties for this climate and new varieties adapted to prairie conditions will doubtless be added to the present list in the near future.

SUMMER-BEARING. *Dunlap* (Senator Dunlap).—The general opinion is that this is the best variety that can be recommended for the prairie plantation at the present time. In many cases it is doing well, particularly in northern districts,

FIG. 33.—A BLOCK OF STRAWBERRY SEEDLINGS OF KNOWN PARENTAGE

Varieties possessing extreme hardiness, drouth resistance and good quality are needed, and these can be obtained only through breeding and the growing of seedlings.

while in a few cases at least it has given disappointing results. The plants of this variety are reasonably hardy, very vigorous and very productive. The fruit is dark crimson in colour with a pink core, medium to large in size, firm, mildly acid and of good quality. The flowers are perfect. This is a good commercial berry. This variety was originated about 1890 by J. R. Reasoner, Urbana, Illinois, and was introduced in 1899 by M. Crawford, Cuyahoga Falls, Ohio.

Dakota.—The plants of this variety are very hardy, are vigorous growers and are very productive. The fruit is bright red in colour, with a deep pink to crimson core, is small to

medium in size, soft, mildly acid to acid, and has good flavour. Preserves made from fruit of this variety have fine colour and flavour and are probably equal to those made from many other varieties. The chief objections to this variety are lack of size and lack of firmness in the fruit. Of the two, lack of firmness is the more objectionable. For home use, however, this may not be very objectionable and the hardiness and the productivity of the plant probably more than make up the shortcomings of the fruit. This also is a perfect-flowered variety. It is a hybrid between Jessie and the wild strawberry originated by Professor Hansen and was introduced in 1907.

Aberdeen.—This variety has been under test for a short time only but it has shown up well to date. The plant appears to be well adapted to the prairie climate and to have considerable drouth resistance. The plants have proved to be vigorous, productive of runners and very fruitful. The fruit has good size, colour and quality. Its flowers too are perfect.

Marvel.—This is one of the more recent varieties and it has given considerable promise as a variety for the prairie provinces. The plants of this variety are moderately hardy and winter well. They are reasonably vigorous and very productive. The fruit is large, is firm, is mildly acid and has good colour with a crimson core. The "seeds" are prominent, however, and there is some tendency for the tips of the fruit to be a little late in ripening. Its good qualities appear to outweigh its bad qualities and a future may be predicted for this variety in certain parts of the West. The flowers are bisexual. This variety has Dunlap and Warfield as parents and was originated by Percy Schuckhardt, North Lake, Wisconsin. It was introduced in 1922 by the R. M. Kellogg Company, Three Rivers, Michigan.

Other varieties of the summer-bearing class have been tested in northern districts and some of these have proved to be unsuited to the climate. Premier, Belt (William Belt) and Easy Picker, however, have shown considerable promise and good reports regarding their performance in northern regions have been received. Premier is an outstanding variety where it can be grown successfully but the plants appear not to be as well suited to many sections of the West as are those of Dunlap. It is a bisexual variety. Easy Picker is a pistillate variety. Beaver, a recent introduction and one that has received very high praise from growers in Minnesota deserves further testing. It has been referred to as the best all-round summer-bearing variety. Some of the other newer varieties such as Blakemore, Red Heart, Narcissa, Fairfax, Dorsett

and Bellmar, which were originated and introduced, by the United States Department of Agriculture, are under test but dependable reports on their behaviour will not be forthcoming for some time.

EVER-BEARING. *Champion.*—This has been one of the most satisfactory ever-bearing varieties for the Canadian prairies. The plants are reasonably hardy, are vigorous, produce a fair number of runners and fruit moderately well. The fruit is dark crimson in colour, is of medium size, is mildly acid and is of good quality. It originated as a chance seedling about 1915 and was first grown by Edward L. Lubke, New Buffalo, Michigan.

Mastodon.—This variety has enjoyed much popularity during the past few years. The fruit is very large, firm and of good quality though somewhat acid. The plant is vigorous and very fruitful. It is one of the best of the tested varieties.

Progressive.—Plants of this variety are only moderately hardy and seem to require a great deal of protection. They are reasonably vigorous, however, and are moderately productive. There is often the tendency of the plants to produce few runners. The fruit is bright red in colour, is mildly acid and is of excellent quality. This is one of the older varieties and is from a cross between Dunlap and Pan American. It was originated by Harlow Rockill, Conrad, Iowa, in 1908 and was introduced in 1912.

Duluth and Superb are two other varieties of this class that have been grown to some extent. These have not given as good an account of themselves in the prairie provinces as have Champion, Mastodon and Progressive.

Dryweather is another variety in this class and is one that is little known. This is a North Dakota introduction and reports from that State regarding its performance have been favourable.

Empire All-Red is a new variety of ever-bearer that is being much advertised and sold. Great claims are made for it but reports on its performance in prairie sections are not sufficiently numerous to permit the passing of judgment on it as a variety for the North at present. It has many desirable qualities.

Wayzata, also known as Rockhill No. 26 and Bonanza, is a new ever-bearing variety for which great claims are made. It has been tested widely in Minnesota and very favourable reports on its behaviour have been forthcoming. It is claimed that it approaches a model variety more closely than other varieties. It is one that is well worthy of a trial.

The Gem or New Gem is another new variety that merits testing. The fruit is of good size and quality and is said to carry its size through the season well. The plants are reported to be markedly drouth-resistant, hardy and vigorous.

Location of the Bed

Protection from the winds is a prime requisite in the successful culture of the strawberry in prairie regions. It is true that plants of the very hardy varieties will thrive under exposed conditions but returns from an exposed plantation are very uncertain and are never large. The strawberry bed should be in a well-sheltered location and for best results protection on the north, west and south sides is necessary. Shelter on these sides will protect the plants against the drying winds from the south-west during the summer and against the prevailing north-west winds during the winter. This protection during the winter will permit the snow to accumulate in the area occupied by the bed and the strawberry plants will thus have additional covering during the season of low temperatures.

The position of the area for the strawberry plantation is important. If there is a choice between a northern slope and a southern slope, the northern slope should be selected. Plants growing on a northern slope begin growing later in the spring than plants growing on a southern slope and such plants may escape injury from late spring frosts where similar plants on a slope facing south are badly damaged. Further, the soil on a northern slope dries out less quickly during the summer than the soil on the southern slope and plants on the latter suffer from lack of moisture earlier than do plants on the former. An eastern slope is more desirable than a southern slope. Good success may be obtained with a plantation on a southern slope, however, if the slope is not steep and if proper cultural treatment is given. In the Great Plains section, there is seldom a choice and it usually becomes necessary to use a flat area. Such an area is satisfactory provided soil and drainage conditions are good.

Good surface drainage is essential in strawberry culture. Low-lying land that is naturally moist is desirable but poorly drained areas and areas that become flooded at any season should be avoided. While strawberry plants will tolerate being under water for a short time in the spring when the ground is still frozen and the plants dormant, it is advisable to select an area that is free from submergence even when

deep snow prevents the normal flow of water to the lowest places.

Soil and its Preparation

Any good garden soil is satisfactory for the strawberry plantation. Soil that will produce good crops of root vegetables should produce good strawberries. A very heavy soil should be avoided, and one that contains sufficient sand to make it friable should be chosen if possible. Where only a very heavy soil is available such soil may be ameliorated and made suitable for use by heavy applications of sharp sand and well-rotted manure.

The area to be devoted to strawberry-growing should be at least three years from prairie sod and should be fallowed the year previous to that of planting. Before the summer-fallowing is begun a heavy application of manure should be made to the area and ploughed in.

In the spring, the surface soil should be stirred thoroughly as soon as the land is dry enough to work. Before the planting season arrives, the soil should be worked down to a fine condition and its surface made as even as possible.

Propagation

The strawberry may be propagated by seed, divisions and runners. Plants produced by seed may not possess the varietal characters of the parent and new varieties are produced in this way. Division of the old plants is resorted to only when a variety cannot be propagated readily by runners. The usual method is by runners.

Propagation by Runners.—The runners that are used in propagating the strawberry are produced during the previous summer. Well-established plants develop runners during the growing season, and at definite places on these runners —at certain joints—new plants are formed. Leaves appear and when the joint is in contact with moist soil, rooting takes place. Rooting progresses rapidly and soon the plant becomes independent. After the new plant becomes established, and becomes independent, the connecting part of the runner dies and may be severed without injury either to the young plant or to the parent plant. These young plants in turn send out runners and the process described is continued normally until late summer or early autumn. This may

continue until many runner plants have arisen either directly or indirectly from the mother plant.

Propagation by Seed.—Where seedlings are to be grown the ripe fruit is gathered, crushed and the "seeds" washed out with water. The "seeds" are spread out to dry and after drying they are placed in an envelope or bag for storage at ordinary room temperatures. Special pre-germination treatment is unnecessary, and when seeding time arrives the "seeds" are sown in the ordinary way. Only a light covering of soil should be given, however. The usual plan is that of sowing the "seed" in boxes indoors in February or March, transplanting the young seedlings to other boxes after the seedlings are large enough to transplant easily and setting the plants outdoors in June. The plants should be set far enough apart to permit the keeping of the plants separate. Such plants will flower and fruit the following year if growing conditions are favourable.

PLANTING STOCK

Selecting Plants.—When a new plantation is to be established some of these young runner plants are dug up and are set in the new location. It is such stock that is supplied by nurserymen. Only the best plants should be used. Plants produced early in the season and which are found near the mother plant are usually the strongest and are the most desirable. The plants at the edge of the old row are usually weaker than those near the centre of the row, owing to their having been produced late in the season, and should not be used unless it is necessary to do so. Only those with numerous fibrous roots should be selected for planting. Plants with dark-coloured roots usually lack vigour and should be discarded.

Obtaining the Plants.—Strawberry plants should be obtained as near home as possible. This class of nursery stock does not lend itself well to long-distance shipment, and in most cases plants received from distant points suffer a very high mortality. The best source is one's own garden. If it is necessary to obtain them away from home, the nearest dependable grower should be favoured with an order for plants. Nurserymen specializing in the production of strawberry plants frequently supply better stock than those in the general nursery business and, where distance is not an important consideration, the specialist should be given the preference.

Systems of Culture

Two systems are followed in the culture of the strawberry. One is known as the "matted row" and the other the "hill" system. In the matted-row system many plants are permitted to develop and each row consists of a mat of plants eighteen to twenty-four inches in width. In the hill system no young plants are allowed to develop, and the plantation consists only of the plants that were set out when the plantation was started. Each system has its advantages, but under average conditions the matted-row system is probably the better. In a small back-yard garden where the area available for the strawberry plantation is small and where very large fruit is desired, the hill system can be adopted to advantage.

Planting

Plants of the strawberry may be set out any time between the first week of May and September 1st. The earlier the planting is done, after the plants have begun to grow in the spring, the more satisfactory are the results, however. If it is possible to do so, the planting should be done during the second or third week in May. At this time the atmosphere is usually cooler and moister than it is later and the plants can get established more easily and more quickly than is possible later in the season. Further, plants started early in the season make more growth and produce more runners than plants started late in the season.

Spacings.—In the matted-row system the plants are set from fifteen to eighteen inches apart in the row, and the rows are made three and one-half or four feet apart. In the hill system the plants are usually set twelve inches apart in the row and the rows about three feet apart. Double rows, twelve inches apart in place of a single row, and with three feet between the pairs, might be used where conditions are favourable. They may be set closer than this and are sometimes set twelve inches apart each way. The latter spacings may be used on small properties where land is not plentiful and where irrigation can be practised.

Setting the Plants.—Holes for the plants may be made either with a spade or with a trowel. The roots should be spread out, in order that all parts of them may be in close contact with the soil after the planting is done. Each plant should be set so that its crown is on a level with the surface of

the earth and neither above nor below it. Plants that have made considerable growth before being transplanted should have their leaf areas reduced by the removal of all but one pair of leaves at the time of transplanting. This treatment reduces the evaporating surface and aids the plant in establishing itself in its new location.

If many plants are to be planted, two persons can frequently work together to advantage. In such a case, one person makes the opening for the plant by forcing the spade into the soil at an angle and thrusting the handle forward slightly.

FIG. 34.—THE PROPER AND IMPROPER LEVELS AT WHICH TO SET STRAWBERRY PLANTS

Left—too high; right—too low; middle—correct level.

After this has been done the second person places the plant in the opening below the spade to the proper depth and spreads its roots as directed above. The spade is then withdrawn and the soil is allowed to fill the opening made and to cover the roots of the plant. The operation is completed by applying either the toe or the heel to the loose soil in contact with the roots and filling the depression made by the toe or heel with surface soil. Where only a few plants are being planted, a garden trowel is an excellent tool to use in making the hole to receive the plant. This tool may be found satisfactory even where a large plantation is being started.

Great care must be exercised when handling the plants not

to allow their roots to become dry. The roots of plants that have come a great distance should be placed in water immediately after the shipment arrives and left there for twelve hours. The plants should then be set out without further delay. Plants taken from a near-by plantation require no preliminary treatment and should be replanted at once. A vessel containing water and clay may be kept in the field to advantage when the planting is being done and the roots of the plants to be set kept submerged in this mixture, until the holes are ready. The plants can be taken one by one from the vessel as needed and planted before the roots become dry.

If the ground is without abundance of moisture the plants should be given a thorough watering at planting time. A slight depression should be left around each plant and this filled two or three times with water. After the water has disappeared, the moistened surface should be covered with dry surface soil.

The use of water even when the soil is moist is a distinct advantage. Water brings the soil in close contact with the roots and thereby provides more favourable conditions for rooting.

Training the Plants

In the Hill System.—When the hill system is being followed, the runners are removed soon after they appear. This prevents the multiplication of plants and the number of plants in the plantation remains the same as it was at the beginning. All flowers that appear the first season on plants of summer-bearing varieties should be removed. Not being allowed to produce either runners or fruit, the plants increase in size very rapidly and by autumn they should possess large crowns. These plants will produce a great number of large berries the following year if environmental conditions are favourable.

In the Matted-row System.—In the matted-row system all the runners are allowed to develop and produce plants. A runner may develop in any direction and many will run at right angles to the row. If the runners were allowed the freedom of the plantation, the entire area planted would be covered by plants eventually. It is good practice, and it is very desirable, to train the runners in the direction of the row and to retain a strip between the rows unoccupied by plants for purposes of cultivation and harvesting. While trained in the direction of the row the runners should be

placed on one side of the original line of plants as much as possible. The runners should be placed by hand and should be so spaced that the plants will stand about six inches apart each way. In order to root, the joint of the runner that is to produce a new plant must be in contact with moist earth and during dry weather at least it becomes necessary to cover the joints lightly with soil. The row should not be allowed to cover an area much more than eighteen inches in width. This will leave a strip twenty-four to thirty inches in width between the rows, and such a strip is sufficiently wide to permit giving the plantation the attention it requires.

Fertilization

The strawberry usually responds well to application of fertilizers carrying readily available nitrogen and phosphoric acid. Such a fertilizer is important during the period of vegetative growth and at the time of fruit-bud formation. Applications have been found to increase greatly the number of flower clusters per plant, the number of flowers per cluster and the percentage of flowers setting fruit.

A good fertilizer combination to use is ammonium sulphate and ammonium phosphate. Equal parts of these salts should give good results. One pound of each may be applied to each two hundred and fifty to three hundred square feet of surface to be fertilized and these may be mixed and applied together. Mixing the fertilizer with double the amount of dry sand or dry sifted soil will facilitate making a uniform distribution. The fertilizer may be broadcast and should be raked in.

Two applications should be made each season. The first application might well be made about a week or ten days after the plants have been set out and the second application early in July. In subsequent years the first application should be made soon after the plants begin to grow in the spring and the second at the same time as in the first year. The applications should be made just before a rain if this is possible.

The applications made the first year need not be distributed over the entire ground surface. It should, however, be distributed to a point at least a foot beyond the outside plants.

Winter Protection

Strawberry plants require a protective covering during the winter and early spring months. Even if the plantation

is well sheltered on the north, west and south sides, an artificial covering is of material value in reducing winter injury and in increasing the yield of fruit.

Injuries caused by Low Temperatures.—Experience indicates that strawberry plants frequently suffer from injury through exposure to low temperatures and winds during the winter, injury resulting from freezing and thawing during the spring and injury through the destruction of flowers by late spring frosts. The injury from any one of the causes mentioned may be sufficiently severe either to reduce greatly or to destroy the crop of fruit. Frequently all three causes operate, each taking its toll, and where this occurs, the results to the crop are disastrous. Plants unduly exposed during the winter are likely to be subjected to temperatures that will destroy their tissues. The drying winds of winter may remove moisture from unprotected plants more rapidly than the plants can take moisture from the soil and drying-out will result. If this continues day after day, death of the plants will inevitably result. Even though the plants have survived the winter, failure to secure a crop of fruit may result through the destructive action of frost early in the spring. At this season, the soil around the roots of the unprotected plants gives up some of its frost during the day and freezes again during the night. Through this expansion and contraction of the soil, the plants are drawn from their moorings and if marked fluctuations in temperature continue to occur, some of the plants may be found lying on top of the ground with their roots fully exposed to the sun and atmosphere. And even though the strawberry plants have succeeded in reaching the growing and flowering stages in the spring a crop of fruit is not assured. Frequently a belated spring frost visits the plantation and all the early flowers, and sometimes many of the late flowers, are destroyed. Even when the late flowers are not injured by such a frost, the results are disappointing.

Mulching.—Much may be done to ensure a bountiful crop of fruit and to prevent disappointment by mulching the plantation soon after winter sets in. A covering applied at this time protects the plants by preventing excessive evaporation from the parts above ground during the winter and by preventing the undue freezing and thawing of the ground that occurs in the spring where the ground lies bare. Further, it protects the flowers by delaying the blooming period. It is a common observation that ground covered by a mulch remains frozen in the spring long after that fully exposed has

given up its frost. Not until the soil reaches a temperature at least a few degrees above the freezing point do most plants begin to grow, and the soil in a mulched area may be ten days or two weeks later in reaching a growing temperature than the soil in an exposed area. Strawberry plants that are mulched, therefore, may be delayed from one to two weeks in resuming their growth activities in the spring. This delay of ten days or two weeks in the resumption of growth is equivalent to a delay of a week at least in the opening of the first flowers. When late spring frosts frequently take a heavy toll of flowers this difference of a week may be sufficient to save the greater part of the crop fruit.

Various materials may be used for mulching the strawberry bed. Manure, chaff, hay and straw all have been used with varying degrees of success. The most satisfactory material, however, for such work is either coarse hay or clean coarse straw. These should be applied to a depth of five or six inches or more soon after the ground has become frozen and just before a fall of snow if possible. The snow will serve as an anchor for the straw and will prevent it from being scattered wide by the winds during the winter. If the mulching material is well firmed at the time it is applied, a covering of snow, to serve as ballast, may not be necessary.

As soon as the strawberry plants show evidence of growth in the spring, the mulch should be removed. If left on too long the covering will destroy many of the plants. In a normal season this mulch need not be removed before the end of April. In some seasons it may be necessary to remove it earlier than this while in other seasons it may be left safely until the first week in May. The finer portion of the mulch may be placed between the rows and the remainder removed, or all may be taken away. The former method may be the better as the mulch between the rows conserves moisture, tends to keep down weeds, and assists in keeping the fruit clean. Where weeds are numerous a mulch may prove a nuisance in not allowing the free use of a hoe, but pulling may be resorted to in such a case. Where the hill system is being used and where close planting is being practised, the use of a mulch may not be practicable.

Treatment during Subsequent Years

During the early part of the second year, the plantation will require little attention. If a mulch has been left between the rows, no cultivation will be necessary. Any weeds that

appear should be removed, and any new runners that appear before fruiting should receive the treatment recommended under "Training the Plants". If all the mulch has been removed and if space will permit it, cultivations should be given as frequently as required. When the hill system is being used the runners must be pinched soon after they appear, to preserve the vigour of the original plant.

Immediately after the fruiting season is over, the mulch deposited between the rows should be removed and the work

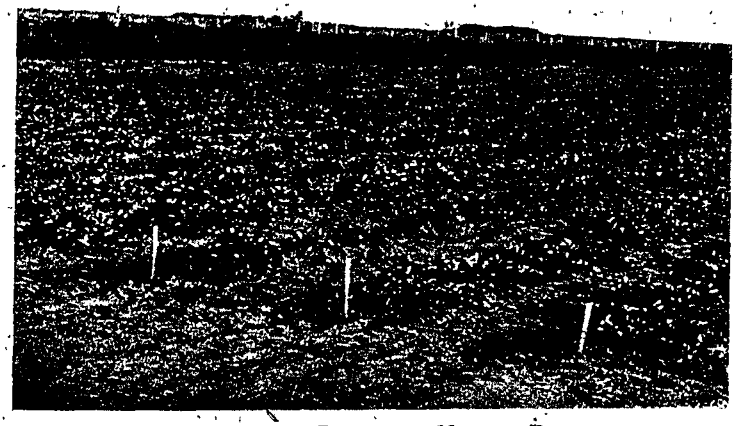

FIG. 35.—STRAWBERRY PLANTS IN MATTED ROWS AT THE DOMINION EXPERIMENTAL STATION, ROSTHERN, SASKATCHEWAN

of renovation begun. Where the hill system is in use, renovation will consist only in removing the weeds and in stirring the soil around the plants. Frequent cultivations should be given during the remainder of the season and all runners kept removed. Where the matted-row system is in use little renovation will be necessary the first year of fruiting. Weeds should be kept down and the runners produced should be trained to the side of the row opposite to that to which the runners were trained the first year. This results in most of the one-year-old plants being on one side of the original line of plants set out and most of the new plants being on the other side.

The following year two sets of plants will be fruiting. One set—those on one side of the original line of plants—will be two years old and will be producing their second crop of fruit. On the other side will be the one-year-old plants that will be fruiting for the first time.

Immediately after the fruiting season of the second year is over the rows should be narrowed. All the plants in the older half of the row should be removed and only the half containing the one-year-old plants left undisturbed. This may be done by hand or it may be done with a horse and plough. The runners produced from this time on should be trained to one side of the row—either to the cultivated strip between the rows and that has been kept clean or to the strip from which the old plants have been cleared.

Immediately after fruiting the following year the plants in the two-year-old section of the row are removed, as in the previous year, and the new runners trained to one side. This plan is continued until the soil becomes impoverished and the moving of the plantation is considered advisable. This is essentially a system of renewal. Two-year-old plants are discarded each year and new runners are trained to take the place of the old plants removed.

Life of a Plantation

Whether or not it will pay to retain a bed depends upon the condition of the plantation. As long as the plants retain their vigour, the weeds are kept down and the bed remains productive, the starting of a new plantation is unnecessary. Where the renovation can be done with little labour, and where the soil is fertile, a bed may be retained for four or five years. Under less favourable conditions it may become necessary to start a new plantation every three or four years. Many growers plan to fruit a plantation only two years and to start a new plantation every second year.

Owing to the tendency of strawberry plantations to become weedy with age it may be advisable in some cases to start a new plantation each year. Only one crop of fruit would be taken from a plantation in this case and immediately after the fruiting season was over the plantation would be broken up and the plants destroyed.

Pests

Strawberry Flea-beetle (Haltica ignita Illiger).—This is a small bluish-green beetle, measuring about one-sixth of an

inch in length, that feeds on the foliage of strawberry plants in the spring. The pest usually appears in large numbers and the leaves become riddled in a short time. Only the adults attack strawberry plants. The females lay their eggs on plants of the evening primrose and its relatives and the larvae feed on these.

Strawberry plants are protected against this pest by a thin coating of some compound that is harmless to the plant. Air-slaked lime or common flour dusted on thinly will drive the beetles away. A few of the beetles may be poisoned by using an arsenical with the other material dusted on but the number is likely to be so small that such a measure is not worth while.

DISEASES.

Powdery Mildew (caused by Sphaerotheca humuli *(Fries) Burr.)*—This is probably the only fungous disease attacking strawberries in Saskatchewan that is worthy of mention and even it seldom does serious injury. The author has seen severe cases of it in plantations that were being irrigated by overhead sprinklers at very frequent intervals.

Leaves of plants attacked tend to roll and their under-surfaces become exposed. These under-sides become somewhat purplish in colour and are found to be coated with a whitish powdery growth. The leaves attacked may dry up and die where the infection is heavy.

This mildew is the same as that found on the red raspberry and the control measure that should be tried is that of dusting with sulphur as recommended for mildew on raspberry. The giving of frequent overhead irrigations should be avoided. Where possible the water given should be applied direct to the soil without wetting the foliage. Where overhead sprinkling must be resorted to, each sprinkling given should be sufficiently heavy to wet the ground well and to eliminate the necessity of frequent irrigation. Further, the sprinkling in this case should be given early in the day to permit the foliage to become dry before evening.

Degeneration.—This term is used to designate certain abnormal conditions found in the strawberry plants. It usually comprises: Yellows—a yellowing of the foliage; Leaf Curl—an abnormal curling and rolling of the leaves; Crinkle—leaves become crinkled; Dwarf—plant develops numerous leaves but is obviously dwarfed; Red Plant—foliage becomes much reddened; Small Leaf—leaves are numerous but are very small; and Cauliflower—the plant forms a rosette suggesting a cauliflower.

Much remains to be done in the study of these diseases. Considerable difference of opinion as to the agent responsible for a given disease of this type is found. It is definitely known, however, that certain agents are responsible. The most important of these are root-rots, viri, insects and other animals.

Eel-worm is responsible directly for some of these troubles. Viri play an important part in bringing about some of these conditions but there is lack of uniformity in the findings of investigators as to which diseases are caused by this agent. Aphids are instrumental in the spread of viri and thus are responsible indirectly for degeneration in certain cases. Mites injure the plant directly and through spreading viri they bring about injury to the plant indirectly. Root-rots attacking the strawberry are numerous and probably no small part of the so-called degeneration in plants of this fruit is traceable to these.

It is not known how many of these forms of degeneration in the strawberry occur in the prairie provinces. Some of them do occur and some injury is done but the losses resulting are probably small in most cases.

CHAPTER IX

THE RASPBERRIES

THE raspberries are among the most popular temperate fruits grown. Both in the fresh and preserved conditions, the fruits of most forms are delightful to the palate and are enjoyed by all. Large quantities of fruit may be obtained from a few plants and, where conditions are favourable, sufficient to meet the needs of the average family may be harvested from a plantation of fifty to one hundred hills.

BOTANY

The raspberries belong to the genus *Rubus*. The underground part of the plant is perennial, but the canes are biennial. The stems are usually prickly and stand more or less erect. The leaves are arranged alternately and in most cases are compound with from three to seven leaflets. The flowers are borne in small clusters on short shoots that arise in the axils of the leaves on canes produced the previous year. The flowers are of moderate size and are usually perfect. The calyx and corolla each have five parts and the petals are usually white. The stamens are numerous and are attached to the base of a disk which is an outgrowth of the receptacle. While separate, the numerous pistils are crowded on the receptacle. The receptacle is usually convex but, in some cases, it is flattened.

The fruit is an aggregate. In the raspberries, the ripe druplets separate readily from the receptacle and when the fruit is picked the receptacle is left on the plant. In contrast to this, the ripe druplets of the blackberry and dewberry cling to the receptacle and the receptacle is contained in the harvested fruit.

Cultivated raspberries are of four species mainly. These are Black Raspberry (*Rubus occidentalis*), Purple-cane Raspberry (*Rubus neglectus*), American Red Raspberry (*Rubus strigosus*) and European Raspberry (*Rubus ideaus*). All but the last mentioned are native to America. *Rubus idaeus* is not cultivated extensively in America, and all the varieties recommended for the Great Plain region are of *R. strigosus*. The latter species has a wide geographical range and is found

growing wild north of latitude 55 in the prairie provinces of Canada. *Rubus occidentalis* and *R. neglectus* are less hardy than *R. strigosus* and do not occur as far north as this species.

Two native species, the fruits of which are used to some extent, are *Rubus chamaemorus* and *Rubus arcticus*. The former is known as the cloudberry and the latter as the Arctic raspberry. The plants of both species are low-growing herbaceous plants, producing fruit that is red or yellowish in colour.

Development

Red Raspberry in Europe.—Doubt exists as to the time at which domestication of the raspberry began. Pliny made mention in his writings of wild raspberries having come from Mount Ida. Palladius, a Roman writer of the fourth century, listed the raspberry as a garden plant of his time. Mention was not made of the raspberry again in literature until the sixteenth century when Turner recorded it as growing in gardens in England. Parkinson devoted a whole chapter of his *Paradisi in Sole Paradisis Terrestris*, which appeared in 1629, to a discussion of the raspberry. He noted that both white and red raspberries were grown at that time. In 1729 Langley named only three varieties of this fruit, the white, the red and the purple. When writing in the *Universal Gardener and Botanist* in 1778 Thomas Mawe and John Abercrombie made reference to four varieties of the raspberry. These were Common Red, White Fruited, Twice-bearing Red, White and Smooth. The twice-bearing form, they stated, bore one crop of fruit in July and a second crop in September. The stems of the smooth variety were without arms. These are probably the first references in literature to double-cropping raspberries and to a smooth-cane variety.

While the mention of the raspberry was made by writers in the years that followed, this fruit attracted little attention until the beginning of the nineteenth century. Three varieties were listed as illustrated by George Brookshaw in the second edition of his *Pomona Britannica* which appeared in 1817. These were Red Antwerp, White Antwerp and Common. A catalogue of fruits issued by the Horticultural Society of London in 1825 contained a list of twenty-three varieties. From that time on varieties increased in number rapidly and some of those appearing during this early period are well known at the present day.

The European species was introduced to America about the end of the eighteenth century or the beginning of the

nineteenth century. It was soon found that this species was unsuited to conditions in America. Lack of the necessary hardiness and lack of resistance to drouth and to the extreme heat of summer prevented it from becoming firmly established on American soil.

Development of Red Raspberry in America.—The first mention of varieties of the American Red raspberry was made in 1771. In this year plants of three varieties, English Red, American Red and White were listed for sale by William Prince, Flushing Landing, New York. In 1790 another variety, Large Canada, evidently known later as Canada Red, was added to the list. Of this list of four varieties being cultivated at the end of the eighteenth century only one, White, was of the European species. The name of the variety English Red was changed to Common Red later and this was, so far as records show, the first variety of the native raspberry. This, however, proved not to be a true red raspberry but a hybrid between the native red raspberry and the native black raspberry. While Hedrick regards Canada Red as probably the first pure-bred native red raspberry, there is evidence that American Red which appeared on Prince's list of 1771 was the first. In 1832 William Robert Prince, son of William Prince, listed in his pomological manual eighteen varieties, only four of which were American. In the years that followed little interest was taken in the development of the native red raspberry. In 1853 the American Pomological Society recommended four varieties for general cultivation, all of which were of European origin. Two of the first varieties of *R. strigosus* to become prominent were Stoever and Brandywine. The former variety fruited for the first time in 1859 in the garden of Jefferson F. Stoever, Tacony, Pennsylvania, and the latter is said to have been originated about 1874 by Mr. Miller, who lived by Brandywine Creek, near Wilmington, Delaware. Cuthbert, one of the most widely grown varieties at the present time, was found as a chance seedling in 1865 by Thomas Cuthbert of Riverdale, New York. New varieties followed rapidly and many of the long list of present-day varieties owe their origin to the last three decades of the nineteenth century.

Recent Development in Red Raspberry.—Of the various contributions made in raspberry development in the present century Hansen's is one of the most outstanding as far as very northern districts are concerned. Professor N. E. Hansen set out to obtain raspberries possessing good quality and sufficient hardiness for the most northerly settled parts.

He hybridized northern forms of the wild raspberry with cultivated varieties, one of which was Minnetonka, a variety originated about 1890 by F. J. Empenger, Maple Plain, Minnesota, and reputed to be very hardy. Several varieties of his have been introduced among which are Sunbeam and Ohta, which were introduced in 1906; and Moonbeam, Fewthorn and Starlight which have been introduced since then.

Developments in the raspberry of note have been made at the Minnesota Fruit Breeding Farm, St. Paul, Minnesota, and the Fruit Experiment Station, Vineland, Ontario. The former station originated and introduced Latham and Chief, two varieties that possess marked hardiness for the type and that are proving popular over a wide area. The latter station originated and introduced Viking, a high-class variety that shows up well under a great variety of conditions.

Black Raspberry.—The domestication of the black raspberry dates back to 1832. In that year Nicholas Longworth, Cincinnati, Ohio, discovered and named the Ohio Everbearing, the first cultivated black raspberry. It was not until after 1850, however, that much progress was made in the domestication of this fruit. The propagation of this raspberry presented difficulties and not until a practicable means of making increase was discovered could varieties be made available. In 1850 H. H. Doolittle, Oaks Corners, New York, discovered that propagation could be effected readily by tip-layering and this marked the beginning of the period of rapid improvement of the species. Other varieties appeared but the popularity of the fruit increased slowly. The fruit of the red form was more in demand than that of the black and it was not until dried black-caps became an article of commerce in the 'eighties that the growing of this fruit received a stimulus. With the increased plantings that were being made came a demand for better varieties and since that time many improved black raspberries have been originated and introduced.

Purple-cane Raspberry.—The first variety of the purple-cane raspberry to be domesticated, it has been found, was English Red. This originated prior to 1771 and was thought to be a variety of the native red species until its identity was established many years later. Prince changed its name to Common Red in 1832. A variety received by Prince from a London nursery as a red raspberry and described by him in 1832 also proved to be of this type. This was the variety Prince named Pennsylvanian. In his *Small Fruit Culturist*, which was published in 1867, Fuller expressed the belief that

the purple-cane raspberry was a form of *R. occidentalis*. Believing this raspberry to be a distinct species, Charles H. Peck, State Botanist of New York, gave it the name of *Rubus neglectus* in 1869. In 1870 C. F. Austin expressed the view that *R. neglectus* was a hybrid between *R. strigosus* and *R. occidentalis*. Breeding tests have supported Austin's view and have demonstrated that purple-cane raspberries result from hybridizing the red and the black raspberries. There is evidence, however, that our purple-cane varieties have as one parent *R. idaeus* and not *R. strigosus*, as was Austin's contention. This is a point that can be determined definitely only by extensive breeding tests.

While numerous varieties of the purple-cane raspberry have been introduced few are widely grown. The two most popular are Shaffer and Columbian. The former was originated about 1871 by George Shaffer, Scotville, New York, as a chance seedling. The latter was a seedling of Cuthbert, with Gregg as the probable male parent, and was originated in 1888 by J. T. Thompson, Oneida, New York.

Classes Grown

The only class of raspberry recommended for culture in the prairie provinces of Canada is the red. The black raspberry can be grown in this region, but the returns received in most parts are not sufficient to warrant the expenditure of the effort necessary to maintain the plantation. Plants of the purple raspberry are usually considered less hardy than those of the black and are not suitable for culture on the Canadian side of the international boundary. In southern Minnesota, the black and purple raspberries do very well. The results from tests made in North Dakota and Montana are not very unlike those obtained in the prairie provinces, and only the red species can be recommended for general culture in most parts of those States.

Varieties of Red Raspberry

Many varieties of the red raspberry have been found to be valuable for the home garden. The plants of these varieties are moderately hardy in sheltered locations, and the fruits of a few at least are of fine quality. Probably the most desirable varieties for the home garden in the northern part of the Great Plains region are as follows:

Herbert.—This is a Canadian variety originating as a

chance seedling found in the garden of R. B. Whyte, Ottawa, Ontario, in 1887. The plant is moderately hardy, very vigorous and very productive. The fruit is large, juicy, of good colour, of excellent flavour and reasonably firm. This is one of the best varieties, and is regarded by some as the best variety grown in this region. This variety is to be strongly recommended where winter covering is practised.

Latham.—This is a product of the Minnesota Fruit Breeding Farm, St. Paul, Minnesota, and originated from a cross made in 1908. It was first sent out in 1914 under the name of Minnesota No. 4, but was not given its present name until 1920. It is one of the leading raspberries in the Great Plains region. The plants are moderately hardy, vigorous and usually very productive. The fruit is large, of good colour, but not quite equal to Herbert in quality. It has a tendency to crumble. A winter covering is necessary for plants of this variety.

Newman.—This variety was originated by C. P. Newman, Ville La Salle, Quebec, from a mixture of seed of Herbert, King, Louden, Cuthbert and Eaton sown in 1909. It was introduced by the New York State Fruit Testing Association, Geneva, New York. The plants are reasonably hardy, are strong, have few slender prickles and yield well. The fruit is of good colour, is large and juicy and is of good quality. The plants should be given a winter covering.

Viking.—This variety originated at the Fruit Experimental Station, Vineland, Ontario, and was introduced in 1923. It is superior to many of the older varieties and gives promise of being a leader in its class. The plant appears to be quite as hardy as Herbert, is very vigorous and very productive and is almost thornless. The fruit is large, firm, of good colour and of excellent quality. This variety has not been grown sufficiently long in the West to permit of being recommended definitely, but it is one that is likely to occupy a prominent place in variety lists of this fruit in the near future. Plants of it too require a winter covering.

King.—This is one of the older varieties. It was originated by T. Thompson, Richmond, Virginia, and was introduced by the Cleveland Nursery Company, Rio Vista, Va., in 1892. The plant is a moderately strong grower and is a good performer. The fruit is of medium size with fair quality but usually lacks firmness.

St. Regis (*Ranere*).—Until 1912 this variety was grown as Ranere. In that year it was introduced as St. Regis by J. T. Lovett Company, Little Silver, New Jersey. It bears two

crops of fruit and is frequently referred to as an ever-bearing variety. One crop is produced at the usual time during the summer on canes of the previous season and the other in the fall on new canes. The fruit is inclined to be rather small and lacking both in firmness and quality.

Chief.—This is a promising variety from the Minnesota Fruit Breeding Farm that originated as a seedling of Latham self-pollinated. It was introduced in 1927 but was not named until 1930. The plant is moderately hardy, very vigorous and very fruitful. The fruit is good quality, being an improvement on that of Latham, but is of medium size only and is light red in colour. It has not been widely tested in the prairie provinces, but reports on it have been very favourable.

Sunbeam.—This variety was introduced in 1906 by Professor N. E. Hansen, Brookings, South Dakota. The parents were Shaffer and a wild red raspberry from North Dakota. It is very popular in the colder parts of the Great Plains area because of its reputed extreme hardiness. The fruit is of medium size, of good colour, but of fair quality only. The plant is vigorous and productive. Plants of this variety are seldom covered for winter and in most cases they come through without much injury.

Ohta.—This also is one of Professor Hansen's originations of 1906. Introduction took place in 1912. The female parent was a wild red raspberry and the male parent Minnetonka Ironclad. The plant is very hardy and very productive. The fruit is of medium size only, lacks firmness and colour and possesses only fair quality.

Newburgh.—Of the newer varieties Newburgh has probably received the most favourable comment. Its parents are Newman and Herbert, and it originated at the New York (Geneva) Experimental Station. It was introduced in 1929. The plant is very vigorous with a tendency to branch. The fruit is large, dark red and of very good quality. It should be regarded at the present time as one for testing only.

Certain other varieties are being grown successfully. Some of these are Louden, Miller, Shipper's Pride, Starlight and Moonbeam. All are giving satisfaction in a measure. Starlight, an introduction of Professor Hansen's and one that is of the same parentage as Ohta, has received special praise from certain growers. It cannot be regarded as a variety of high quality, but the extreme hardiness of the plant gives it a place among varieties for the North. Cuthbert and Marlboro are too tender to be recommended for culture in this region.

Varieties of Purple-cane and Black Raspberries

Varieties of these raspberries cannot be recommended. Some success has been attained in this region in the growing of certain varieties, however, and some of these will be mentioned.

The Potomac purple-cane raspberry is being grown successfully, and fruit is being produced in quantity at Zelma, Saskatchewan. The grower reports that the canes have wintered well without covering and fruited heavily when the red raspberry crop failed owing to insufficient moisture. It was originated by the United States Department of Agriculture in 1921. Newman and Plum Farmer, a black raspberry, are the parents. The plant is described as being hardy, very vigorous and very productive. The fruit is large, firm and of very good quality. If it possesses the hardiness and drouth-resistance evidently shown at Zelma this variety will have a place among raspberries for northern districts.

The Cardinal is a variety of purple-cane raspberry that is being grown to some extent in North Dakota. Hedrick states that this variety can be grown farther north than any other variety of this type and it is one that might well be tried in the prairie provinces. Both the plants and the fruit are desirable.

In black raspberries, Hilborn and Kansas have fruited reasonably well in the north. Hilborn has borne considerable fruit in the plantation of the University of Saskatchewan and Kansas has fruited in a private garden in Saskatoon. Careful nursing has been required in both cases. Hilborn is doubtless one of the hardiest black raspberries and its fruit is of good size and of good quality. It is an old variety originated by W. W. Hilborn, Arkona, Ontario, and was introduced by him in 1886. There are doubtless cases in the north where other varieties have been fruited successfully.

The varieties Plum Farmer, Cumberland and Shepperd are being grown and are giving reasonably good yields in North Dakota when the plants are well protected. These varieties might be grown successfully, in some measure at least, in very favoured locations in the prairie provinces.

Propagation

Propagation by Suckers.—The usual method of propagating the red raspberry is by suckers. During the growing season, the plants of this fruit produce, from their roots,

shoots in large numbers. These shoots are termed "suckers", and they may appear close to the plant or at some distance from it. In the case of well-established plants, suckers may appear fifteen to twenty feet from the original plant. These suckers serve to perpetuate the species and are used as plants for starting a new plantation.

Propagation by Division and Root-cuttings.—Other methods of propagating named varieties of the red raspberry are by root-cuttings and by division of the old plants. Division of

FIG. 36.—A YOUNG RASPBERRY PLANTATION AT THE UNIVERSITY OF SASKATCHEWAN A FEW WEEKS AFTER THE PLANTS WERE SET OUT

the old plants is seldom satisfactory, but root-cuttings may be used to advantage when the amount of propagating stock is small. The cuttings are made from two to three inches long and from roots that are at least three-sixteenths of an inch in diameter. These may be taken either in the autumn or spring, but those taken in the autumn are more satisfactory than those taken in the spring. If taken in the fall, they should be stored in moist sand in a basement where the temperature can be kept close to the freezing point, or buried shallowly in moist soil outdoors. These cuttings are planted early in the spring. If taken in the spring the cuttings are planted at once. In either case, the cuttings may be planted from four

to six inches apart in a row in the garden and two or three inches in depth. The plants resulting should be left in this row until the following spring, at which time they may be given the treatment recommended for suckers.

Propagation by Seeds.—Raspberry seeds do not germinate readily. The "seed" of the raspberry is similar in structure to the pip of the plum and cherry and before germination will take place certain changes must be brought about.

A treatment found very satisfactory by the author is one similar to that recommended for the plum. The "seeds" are after-ripened at temperatures near 40° F. during the late autumn and winter and are sown in the spring. They may be sown in soil in boxes in the fall ready for germination later and the boxes placed in a pit for the winter, or they may be mixed with a small amount of moist sand and the mixture placed in a box in a pit. In the spring the boxes containing the sown seeds are placed where conditions for germination are favourable and the seeds mixed with sand are either sown with the sand in soil or are separated from the sand and then sown in soil alone.

Carbonization of the outer bony layer of the "seed" with sulphuric acid may hasten germination. The treatment is not satisfactory, however, as the embryo and tiny seedlings of such "seeds" are not able to resist well attacks by fungi and bacteria and the mortality resulting is very high. The seeds, in this case, are treated for two hours with concentrated sulphuric acid, then washed thoroughly with water and then sown at once without drying.

Propagation of Purple-cane and Black Raspberries.—Plants of these raspberries do not sucker as do plants of the red raspberry and consequently cannot be propagated through the medium of suckers. They can be propagated readily by tip-layering, however. Tips of new canes that have almost completed their development for the season are brought in contact with the moist ground, held there and are covered with moist soil. This soil must be kept moist. Rooting of the tip takes place shortly. Additional soil should be applied as winter is setting in to give protection during the cold months. Early in the spring following, the canes that were bent over are cut about eight inches above where rooting has taken place and the rooted sections dug up and replanted in a row in a suitable location. The portion of cane left is to serve as a handle in transplanting. From the rooted tips shoots will arise and the following spring these new plants are transplanted to the permanent location.

Plants

Where suckers are used in propagating the red raspberry, one-year-old stock should be employed. The most desirable plants are the suckers that were produced during the summer of the previous year. Only strong, healthy plants with good root systems should be chosen. Great care should be exercised in digging suckers to be used and as much of their root systems as possible should be obtained. Plants from tip-layers of the purple-cane and black raspberries should be strong and vigorous.

The Soil and its Preparation

Plants of the red raspberry succeed in a variety of soils, but seldom do well in this climate either in very heavy or in very light soils. A rich, cool, moist, well-drained loamy soil containing considerable sand appears to meet the requirements of the red raspberry in the Great Plains region.

The soil should be in good condition when the planting is done. At least one year's preparation is necessary for good results. In the spring of the year during which the land is to be prepared, a heavy application of well-rotted manure, cow-manure preferably, should be made and the area ploughed. A thorough summer-fallowing should be given during that season and the surface should be stirred frequently to keep down weeds and to conserve moisture. In the spring of the year following, when the planting is to be done, the soil should be cultivated as early as the land ~~is~~ dry enough to be worked and made ready for the plants.

Protection for the Plantation

Protection from the wind for the plantation is a prime requisite in the successful culture of the red raspberry in the Canadian West. With shelter, the plants of this fruit will respond well to good cultural treatment but, without shelter, they will be unthrifty and will produce few fruits. Shelter similar to that recommended in Chapter IV should be provided.

Systems of Culture

Two systems of culture are used in growing the red raspberry. These are known as the "hill" system and the "hedgerow" system. In the hill system, the plants are kept far enough

apart each way to permit working around each plant. If the plantation is large, horse cultivation, both lengthwise and crosswise, may be practised. In the hedge-row system, the plants are allowed to form a solid row one way and horse cultivation is possible in one direction only.

For Saskatchewan, the hill system is probably the more satisfactory under average conditions. The giving of additional protection to the plants for the winter months is usually necessary and this can be given more easily where the hill system is being followed than where the hedge-row system has been adopted. Further, the use of the hill system facilitates cultivation which is so essential in the plains area and is likely to result in a better crop of fruit than can be obtained under similar conditions with the hedge-row system.

The hill system should be employed for purple-cane and black raspberries.

Planting

Plants of the raspberries should be planted as early in the spring as possible. Under very favourable conditions late planting may be satisfactory, but early planting is desirable. Raspberry plants tend to leaf out early and the planting should be done before the leaves begin to show.

Where the hill system is being followed, the plants should be set five feet apart in the row and the rows placed six to eight feet apart. In the hedge-row system, the rows should be six to eight feet apart also but closer planting in the row is to be recommended. Three-foot spacings in the row will result in a continuous row of canes more quickly than will five-foot spacings. In the small garden, where land is not plentiful and where waterings can be given, closer spacings than those recommended may be used. In such cases, spacings as short as three feet each way may be employed provided good cultural methods are adopted. It should be understood, however, that the results under these conditions are likely to be less satisfactory than those where wider spacings are employed.

Direction of Rows.—The direction of rows is of importance in certain cases. Where the hedge-row system is being used, the rows should run north and south rather than east and west. Plants in rows running in this direction usually receive more light and are more uniformly illuminated than those in similar rows running east and west. Direction makes little difference with the hill system, but here, too, a difference may be found in favour of the north and south direction.

When the planting is being done, the usual precautions should be taken. The roots of the plants should not be unduly exposed to the drying influences of the sun and atmosphere and should be kept submerged either in a mixture of clay and water or in water alone until the holes are ready to receive the plants. The holes should not be made, however, many minutes in advance of the planting. The plants should be set about one inch lower than they stood previously and the soil should be well firmed about their roots. Top soil should be used to fill the holes and the heavier sub-soil may be spread over the surface.

After the planting has been completed, some cutting-back should be done. During the transplanting process many of the roots of the plants are destroyed and the balance that prevailed between the roots and the portion of the plant above-ground is disturbed. If this balance is not restored, the plant will receive a severe set-back and death may result in too large a percentage of cases. Since a portion of the root system is destroyed in the transplanting process, the removal of the portion of the part above-ground will assist in the restoration of this balance. Under average conditions it is advisable to cut the stem back to within eighteen to twenty-four inches of the ground surface. This treatment will reduce the evaporating surface and will do much toward assisting the plant to get established in its new location.

TILLAGE

Special directions for tillage are not necessary. During the first season no suckers will appear and clean cultivation should be practised throughout this season. Many suckers will appear during the second season but only those that will be required should be allowed to remain. All those between the rows should be removed soon after they show above the ground surface. If the hedge-row system is being followed, all in the row should remain but, if the hill system has been adopted, considerable blocking-out in the row should be practised, and only those canes near the parent plant in each case should be allowed to develop. Where suckers are required to start a new plantation, extra canes in the row or a few between the rows should be left undisturbed for transplanting at a later date.

During subsequent years one of two systems of management may be used. One system is the same as that followed during the second year, namely, cultivation throughout the

season, while the other is the use of a mulch during the first part of the season and cultivation during the latter part only. If mulching is to be practised, the initial mulch should be applied in the spring of the third year. Clean coarse straw may be used and this should be applied between the rows. Some new canes are required and an area around each group of canes where the hill system is being followed, and a strip from one end of the row to the other where the hedge-row system is being used, should be left unmulched to permit the necessary new growth to take place. This mulch will conserve moisture and will keep down weeds during the early part of the summer. Immediately after the fruiting season is over, this mulch should be removed and the area given two or three shallow cultivations at weekly intervals.

Under most conditions both methods are at least reasonably satisfactory. Where straw is available, however, the mulching method is probably preferable as the covering provided reduces greatly the amount of moisture given off from the soil direct and increases the amount available to the plants. The time required in applying and removing the mulch is probably saved in cultivation during the early part of the summer and the increase in fruit crop that is obtained is likely to be clear profit.

Fertilization

Raspberry plants usually respond well to application of suitable fertilizers. For most plants barnyard manure is unexcelled as a fertilizer and the red raspberry is not an exception in this respect. Every year or every second year at least, an application of manure should be made and this worked into the surface soil between the rows. This should be made in the spring before growth begins.

Where barnyard manure is not available commercial fertilizer should be employed. While information on the use of such fertilizers on raspberries is deficient, ammonium phosphate and ammonium sulphate can be depended upon to give positive results and these should be applied early in May. The best plan is to broadcast them on the soil over the entire area occupied by the plantation, and this should be done before the first cultivation is given in the spring or before the mulch is applied. Where only a single row is being grown the fertilizers should be applied over a strip three or four feet wide at least on each side of the row. One pound of

ammonium phosphate and one pound of ammonium sulphate to each fifty feet of row are suggested. These amounts should be applied to each three hundred to four hundred square feet of surface where more than one row is being grown.

PRUNING

Systematic pruning is essential to success in the growing of raspberries. A raspberry plantation that is not pruned systematically becomes a veritable forest of plants and in a short time the competition between the canes becomes so keen that production falls off rapidly. The canes continue to increase in number and soon the plantation becomes an impenetrable mass of canes, some of which are dead and some of which are living. The small amount of fruit that is produced thus becomes difficult to harvest and the returns to the grower are far from satisfactory.

Fruiting Habits of the Red Raspberry.—As for other fruits, a knowledge of the fruiting habits of the plant is necessary if the pruning is to be beneficial. Any pruning done without regard to the fruiting habits of the plant is usually harmful and in many such cases considerable injury may be done. It is necessary to know on what shoots the fruit is borne if the maximum amount of benefit is to be derived from the pruning and it is desirable to know from what parts of the shoots the main part of the crop is obtained. With this information, the raspberry grower can prune his plants intelligently and can maintain in his plantation a supply of vigorous fruiting wood.

In the red raspberry the fruit is usually borne only on one-year-old canes. Each year new canes or suckers are sent up in large numbers by the roots of established plants. These suckers appear early in the season and continue to grow until autumn. At the end of the growing season they may be five or six feet or more in height. These canes normally winter over and produce the fruit that the plantation bears the following year. The canes bearing the fruit are thus one year old and are produced the year previous to that of fruiting. On these canes the fruit is borne on short lateral branches and these laterals appear normally over the greater part of the cane. Those produced at the top and near the base of the cane are usually weak and bear few fruits while those produced towards the middle are very strong and are very fruitful. Immediately after fruiting the canes die and during the autumn months dead canes will be present in the

neglected plantation. During the summer months of any year, therefore, two sets of canes will be found in the raspberry bed. Early in the season the older set will be found producing flowers and these produce the fruit that is harvested in July and during the early part of August. The other set are the new shoots that have appeared since spring and these will winter over and bear fruit the following year. At the time of harvest the new canes may be taller than the old canes and they may be present in large numbers.

In the so-called ever-bearing varieties fruit is borne on the tips of the new canes in the fall. It is produced also on laterals on one-year-old canes during the summer.

Canes to be removed.—Pruning in the red raspberry consists, therefore, in removing the dead canes and in thinning the new canes where these are too numerous. In many cases differences in vigour are not noticeable and where such are found the strongest and most vigorous canes should remain. Invariably the large canes produce more fruit and larger fruit than do the smaller canes and a careful selection on the basis of size should be made. As stated above, raspberry canes may be kept in hills or they may be grown in a hedgerow. Where the hill system is followed pruning consists in removing all the dead canes and in reducing the number of living canes in the hill to ten or twelve. These should be distributed over an area one and one-half to two feet in diameter and a space between the hills kept clear to permit the giving of the necessary cultivations. Where the hedgerow system is practised all the dead wood is removed and only sufficient of the new canes left to give a stand equivalent to a double row with spacings eight inches each way approximately. The width of the row in this case should not be more than eight to ten inches and this would provide for all the canes required. In both cases attention should be given to alignment and the rows should be kept as straight as possible. If this is done the plantation will have a more pleasing appearance than it would have otherwise and horse cultivation may be practised without difficulty. Short stumps are desirable and the canes removed should be cut as close to the ground as possible.

Cutting back the new canes either in the fall or in the spring is not a desirable practice in this region. Canes cut back late in the summer tend to produce lateral growths that season and these growths are likely to be destroyed during the winter in this climate. A certain amount of tip-killing usually occurs during the winter and this takes the place of

cutting-back in the spring. In regions where the climate is less severe than it is here such pruning is frequently recommended and may be found advantageous in that it tends to increase the size of the fruit. The total yield is reduced by this treatment, however.

Pruning in the purple-cane and black raspberries is similar to that in the red raspberry excepting that the new canes are pinched back when they reach a height of two to two and one-half feet and fewer new canes are left in a hill. This pinching-back induces the production of laterals. If these

FIG. 37.—RASPBERRY CANES PUT DOWN FOR WINTERING

laterals become too long shortening them to eight or ten buds in the spring may be practised.

Pruning Tools.—For pruning purposes any suitable tool may be used. Where only a few plants are to be pruned a heavy jack-knife may be found satisfactory. A knife with a hooked blade is preferable to one with a straight blade and where much pruning is to be done such a knife would prove a great convenience. A secateur is frequently employed for this operation and where the growth is sturdy the use of this tool lightens the task of pruning considerably.

Time to prune.—The best time to prune the red raspberry plantation is immediately after the fruiting season. The wood

that has fruited is no longer of value and the new canes are usually too close to permit the normal development of those that are to bear the crop of fruit the following year. Pruning at this time removes the useless material and permits the remaining canes to become stocky before the advent of winter. Pruning later in the season may be practised if early pruning is not practicable, but it should be resorted to in cases of necessity only. In any case the pruning should be done before the canes are given their winter covering.

Winter Protection

In this climate canes of most varieties of the red raspberry should have special protection during the winter months. Late in the autumn and just before winter is likely to set in, this protection should be given. A practice that is moderately satisfactory in some seasons is that merely of bending the canes down in the direction of the row and covering their tips with earth. This must be done while the canes are in an unfrozen condition. When treated in this way the canes are near the ground and their uppermost parts may be below the snow line during the winter months. In the spring the tips are released and the canes return to their upright positions in a short time.

A method involving the expenditure of more time and labour than the method mentioned above, but one giving complete protection to the plants throughout the entire winter, is that of covering the canes completely either with soil or with straw late in the autumn. Just before winter sets in the canes are bent over in the direction of the row and their tips covered with soil as directed above. If soil is to be used as a covering, this material is banked over the plants until the uppermost parts of the canes are completely covered. A continuous bank of soil from one end of the row to the other is required for plants in a hedge-row, but this is not continuous where the plants are in hills. Where straw is to be employed the canes are prepared in the same way, are bent over and their tips weighted with soil, but straw is used as a covering for the main portion of the cane in place of soil. Here and there little heaps of poisoned wheat should be put down below the straw to destroy any mice that might take refuge in the straw and that would girdle the canes during the winter. In the spring the soil or the straw is removed, the tips of the canes released and the canes allowed to return to their normal positions.

Plants of the varieties Sunbeam and Ohta are hardier than are those of most of the other varieties mentioned, and growers of these seldom use special winter covering. In most years exposed plants of these varieties come through the winter in good condition.

Plants of the purple-cane and black raspberries should be well covered and the procedure recommended for those of the less hardy varieties of the red raspberry may be followed for these.

FIG. 38.—RASPBERRY CANES BENT OVER AND COVERED WITH SOIL FOR WINTERING

RENEWING THE PLANTATION

A plantation of red raspberry, well cared for, should last ten or twelve years or more. As soon as the plants begin to weaken and fail to respond to stimulative treatments, a new plantation should be started elsewhere. The old plantation may be destroyed as soon as the plants in the new plantation have become well established and begin fruiting.

INSECT AND ALLIED PESTS

Few pests attack plants of the red raspberry in the Great Plains region. Up to the present only two pests have been troublesome though two others have done some damage.

(1) *Red Spider* (*Tetranychus bimaculatis*).—This is a very small mite that is usually found on the under-surface of the leaf. A delicate silken web is constructed and the pest lives under the protection of this web. It feeds by sucking the sap from the leaf. Infested leaves turn yellowish in colour and, if the infestation is heavy, the leaves dry up and drop to the ground. Leaves infested with red spider may be seen on the shoot at the left and normal leaves may be seen on the shoot at the right in Fig. 39. Note the shrivelling in the infested leaves. In many cases a large percentage of the leaves fall prematurely and serious injury to the plant results.

A control measure for this pest that has been found reasonably effective in some cases is that of spraying the infested plants with a mixture of water, soap and sulphur. The proportions are as follows: water, one gallon; soap, two ounces; flowers of sulphur, one ounce. Any good laundry soap is satisfactory, and this should be dissolved in hot water. After solution is complete and cooling has taken place, the sulphur should be mixed with the soapy water. Sulphur is not soluble in cold water and, being heavier than water, it will settle in a short time. While being applied the mixture must be agitated constantly to keep the sulphur in suspension. The first application should be made soon after the first spiders appear, and this is usually soon after the leaf buds open in the spring. The mixture must be applied in such a way that it comes in contact with the pest. Since the pest feeds on the under-surface of the leaf, the spray must be applied from below and the lower surface of the leaf wet. Considerable force behind the spray increases the effectiveness of the treatment. It is very important that an early application be given. At the time the first application should be given the leaves are small and a thorough treatment can be given easily. A second application should be made two or three weeks later if the pest is found present at that time.

If sulphur is to be effective, temperatures of 70° F. or above must prevail. Since such temperatures obtain for short periods only at the season when control is important sulphur may give disappointing results in some cases.

A treatment for red spider that is not dependent on high temperatures prevailing at the time of application and one that has been recommended is that of spraying the infested plants with glue dissolved in water. The solution is made by dissolving one pound of common glue in ten gallons of water. The spray is applied in such a way that the infested parts are thoroughly wet. The under surface of the leaf in particular

must be reached by the spray. The water evaporates from the surface of the plant, leaving the glue, which plays the part of an adhesive and sticks the pest to the leaf or to another part that has become infested. The pest perishes in a short time.

(2) *Raspberry Sawfly* (Monophadnus rubi).—In the injurious stage this pest is a greenish-coloured worm covered with tubercles bearing spines. The adult is a black, stout, four-winged fly about one-fourth of an inch long. These flies

FIG. 39.—RED SPIDER ON RED RASPBERRY

Infested leaves are shown on the two canes at the left and leaves free from the pest are on the canes at the right.

appear in May and the females lay their eggs in the tissue of the leaf between the upper epidermis and lower epidermis. The eggs hatch in a week or ten days and the larvae begin feeding at once. These larvae become full-grown in about ten days and, at this time, they are about three-fourths of an inch long. After becoming full-grown they drop to the ground and enter the soil, where they build cocoons and pass the winter. The injury is done through the destruction of parts of the leaf tissue and eventually the skeletonization of the leaf. In cases of heavy infestation, serious damage may be done.

A simple control measure that is recommended where the

soil about the plants has been well cultivated is that of brushing the larvae from the plants during the warmest part of the day. The majority will be unable to return to the plant and will perish on the ground.

A very effective method of controlling this pest is that of dusting the infested plant or plants likely to be infested lightly with either lead arsenate or Paris green mixed with common flour. One part of the poison may be used with fifteen to twenty parts of flour. This material must not be applied after the fruit is formed owing to the likelihood of the fruit being rendered unfit for use but may be applied with safety before this time. Dusting the infested parts with hellebore is a safe treatment after the fruit is formed. This may be mixed with twice its bulk of flour and applied in this form. This substance loses its poisonous property in a short time when exposed to the air and a treatment may be given if necessary two or three days before the fruit is to be harvested.

American Raspberry Beetle (Byturus unicolor).—This pest was reported in Saskatchewan probably the first time in 1935. An earlier record of its occurrence in this province has not been located by the author. The plantation from which the specimens sent in were obtained was reported to be heavily infested. It is probable that the pest is either widely distributed in this region now or will be in the near future. There is the possibility that the low winter temperatures prevailing in very northern latitudes will do much toward keeping the pest in check.

The adults are small brownish beetles measuring between one-eighth and one-sixth inch in length. They feed on the young leaves and on the opening flowers. The stamens and pistils are frequently destroyed and in some cases, where the pest is prevalent, the fruit crop is a total failure.

The young larvae burrow through the whitish receptacle upon which the berry is borne. These larvae become fully developed about the time the fruit ripens. When full-grown they are nearly white and are about one-fourth inch in length. The mature larvae are frequently found lying between the receptacle and the fruit and when picked a fruit may have a white grub adhering to it.

The control measure recommended where this has been a pest for some time is that of either spraying or dusting the plants as soon as the beetles appear with a good food poison. A spray made from one ounce of either lead arsenate or calcium arsenate to each gallon of water used should be effective.

Dusting with a mixture of one of these poisons with common flour, one part of the poison to fifteen parts of flour, is a good substitute for the spraying. The application should be made before the flower-buds unfold, and must not be made after many flowers have opened.

"*Caragana Red Bug*" (Lopidea dakotae).—This pest has been reported as feeding on the fruit of the red raspberry and destroying the drupelets. It is a sucking insect and it feeds on the juices of the parts attacked. The drupelets are punctured and then collapse. A control measure cannot be recommended at this time but spraying the plants with kerosene emulsion or shaking the immature bugs from the plants into a pan containing kerosene and water may prove to be practicable control measures.

Diseases

Plants of this fruit are not very subject to disease in the prairie belt. Two diseases of considerable importance are found occasionally, however.

(1) *Raspberry Mosaic.*—Plants affected with mosaic are dwarfed and the leaves are mottled in place of being uniformly green. Areas in the leaf become pale green or yellowish, while others retain their normal colour. In many cases overgrowth of the leaf tissues takes place in certain areas and distortion results. The fruit produced by diseased plants is dry and possesses little flavour. In some plantations a large percentage of the plants present are found affected with the disease while in others the disease is absent. No organism has been found definitely associated with the disease and its cause is unknown at the present time. It has been established, however, that the disease can be transmitted from one plant to another by insects and by other means.

The only control measure that can be recommended is that of digging up the affected plants and destroying them as soon as possible after the presence of the disease has been discovered. This should be done as thoroughly as possible and without delay. It is important to remove as much of the root system of the plant as conditions will permit. Where the plantation is badly affected, the best plan is to plough it up and to destroy the plants. A new plantation should be started from disease-free canes on an uninfected area.

For planting purposes, plants should be obtained from plantations that are known to be free from the disease. Reliable nurserymen are not likely to send out diseased plants

and they can usually be depended upon to supply stock with a clean bill of health. The statement is frequently made that certain varieties are more resistant than others to this disease, but there is conflict of opinion in this matter and it is advisable at the present time not to depend on one variety being much more resistant than another. The varieties listed above appear to be as resistant to this disease as do other varieties now in existence.

(2) *Powdery Mildew* (*caused by* Sphaerotheca humuli).—This disease appears not to be very common on plants of the red raspberry in prairie provinces, but it has been found present. In a few cases plants have been found very heavily infected. This disease attacks the leaves and in some cases the shoots and the fruit. The affected parts become covered with a whitish, mouldy growth, which may become very dense on the leaves. Some varieties appear to be more susceptible to the disease than others, but the author is not able to state at the present time which varieties are very susceptible and which varieties are not.

Owing to this disease seldom causing serious injury to raspberries anywhere, very little is definitely known about its control on this fruit. A mildew caused by the same organism attacks the strawberry and hops, and in these cases dusting with sulphur is an effective control measure. There is every reason to believe that dusting with finely divided sulphur will do much toward checking this disease on the red raspberry also.

CHAPTER X

BLACKBERRIES, DEWBERRIES, LOGANBERRIES AND STRAWBERRY-RASPBERRY

THIS group of fruits is of no economic importance in the Far North. The plants of these lack the hardiness necessary in that region and attempts to grow them usually result in failure sooner or later. A few plants are being grown, however, and a small amount of fruit has been produced but very careful nursing and management have been necessary to enable the plants to survive and to give even a small return.

The blackberries have erect canes and the plants are usually strong-growing. The fruit is black and its length is considerably greater than its diameter. It is an aggregate but the juicy portion does not separate from the receptacle as does the fruit of the raspberries. The plants of this type of fruit sucker freely.

The Common High-bush Blackberry (*Rubus alleghaniensis*) is native to eastern North America. It has a fairly wide range and is found from North Carolina to Ontario and Nova Scotia. The canes run up to seven feet in height and are armed with stout prickles. The fruit is elongate, black and sweetish.

Domestication of the native blackberry was recommended as early as 1829. At that time it was recognized as a shrub well deserving a place in the farmer's garden. The first-named variety of this fruit was the Lawton. The original plants were found in 1834 by Lewis A. Seacor, New Rochelle, New York, but its name was not officially adopted until 1856. In 1841 fruit of an outstanding blackberry was exhibited at a meeting of the Massachusetts Horticultural Society by E. Thayer, Dorchester, Massachusetts. This fruit attracted much attention because of its large size and good quality. It was first named Improved High-Bush Blackberry but later its name was changed to Dorchester. The Wilson appeared in 1854 and Kittatinny was discovered and named about 1865. These were a great advance over previous varieties and gave the growing of this fruit a great stimulus. Agawam was discovered between 1865 and 1870, Eldorado in 1880 and Mersereau in 1890. Many other varieties have been named and introduced since then but Kittatinny,

Agawam, Eldorado and Mersereau remain to be some of the most generally grown varieties today.

The Himalaya Berry which was introduced by Luther Burbank early in the nineties is a form of a European Blackberry (*Rubus procerus*). The plants of this fruit are less hardy than those of varieties of the common cultivated blackberry.

The Oregon Evergreen Blackberry is a form of *Rubus laciniatus*, the Common Blackberry of Europe. Plants of this fruit do well in parts of the West but can be grown only with great difficulty east of the Rockies.

The dewberries are characterized by having procumbent canes in contrast to the erect canes of the blackberry. Propagation is effected by tip-layering rather than by suckers. Two species have made important contributions. These are the Northern Dewberry (*Rubus villosus*) and the Western Dewberry (*Rubus loganobaccus*).

Domestication of the dewberries began later than that in the blackberries. The first record of a seedling having been grown was in 1854. The first variety to receive wide recognition was Bartel and the first important commercial variety was Lucretia. Both of these were derived from *R. villosus*.

Two important types of dewberries have been derived from the western dewberry. One of these types is represented by the Loganberry and the other by Mammoth. Both were grown from seed of the western dewberry sown in 1881 and introduced by Judge J. H. Logan, Santa Cruz, California. The former was thought to be a hybrid between the red raspberry and the dewberry but this has been questioned by certain authorities who believe that it is a red-fruited sport of this species of dewberry. Recent cytological findings support the belief that it is not a hybrid but has originated as a mutation. The latter variety is supposed to be a natural hybrid between the Texas Blackberry and the California Dewberry. While having some of the dewberry characteristics this variety is usually listed as a blackberry.

The Strawberry-raspberry (*Rubus illecebrosus*) grows to a height of twelve to eighteen inches and produces a red fruit about the size of a strawberry. The fruit is said to be of poor quality when raw but to be agreeable when cooked. The plants are not hardy in the most northerly sections. This species is a native of Japan.

CHAPTER XI

THE CURRANTS

AMONG the hardiest temperate fruits are the currants. Plants of native species are widely distributed in North America and are found growing north of latitude 60. Plants of many of the cultivated varieties of this fruit appear to be quite as hardy as those of the native species and these may be grown successfully even in the most northerly agricultural districts.

Though not as popular as some of the other temperate fruits the currants are being widely planted in the North. The hardiness of the plants and the suitability of the fruit for culinary purposes are obtaining for them a prominent place in the prairie home garden. No garden should be without at least a few plants of currants and no fruit garden can be considered complete without representatives from the various kinds of this group of bush fruits.

BOTANY

The currants belong to the genus *Ribes*. The plants are woody perennials with more or less upright stems which are free from spines and pickles. The leaves are shallowly lobed and have a dull surface. The flowers are small, usually inconspicuous and are borne in elongate clusters of various sizes. The sepals, petals and stamens are each four to five in number and the pistil is single. The fruit has always been regarded as a berry but is pome-like in structure and is now regarded by some authorities as a pome.

While many species of currants are found, only a few of these are important as sources of fruit. These are *Ribes rubrum* Linn., which is native to central and northern Europe and Asia; *Ribes vulgare*, which is native to northern and western Europe; *Ribes petraem*, which is native to Siberia and to the high mountains of Europe and northern Africa; and *Ribes nigrum*, which is native to Europe and Asia. To the first three the red and white currants belong, and to the last the common cultivated black currants owe their origin. The leaves of the last species are supplied with numerous glands which show as tiny yellowish dots on the under surface of

the leaf. The skin of the fruit also is supplied with these glands. From the secretions of these glands the leaves and fruits derive their characteristic strong odours. *Ribes rubrum* has pinkish or reddish flowers and is without a raised ring or pad on the surface of the ovary, while *R. vulgare* has uncoloured flowers and shows a distinct pentagonal raised ring on the surface of the ovary. The plants of *R. petraem* are characterized by stiff, erect stems, lateness in beginning growth in the spring, deep pink to red flowers, the holding of their leaves in the autumn and by resistance to the attacks of the Imported Currant Worm. The fruits of *R. vulgare* and *R. petraem* are red and those of *R. rubrum* usually red though rarely uncoloured. The flowering currants, *Ribes aureum* and *Ribes odoratum*, which are native to America and which are grown chiefly as ornamentals, have given a few varieties that are grown for their fruits. The flowers of these species are rather showy and have long yellow calyx-tubes surmounted by small reddish petals. The fruit varies in colour, and forms producing black, red and yellow fruits respectively are found. The plants are uncertain bearers and while some bear well many bear little or no fruit. *Ribes hudsonianum* and *Ribes floridum* both occur in the wild state in the prairie provinces and their fruits are frequently used but are usually considered inferior to those of cultivated varieties. *Ribes petraem* is fully hardy in the Canadian West and may make a contribution to hardy currants for that section.

Development

Like the gooseberry, the currants have been under cultivation for a few centuries only. The currants were probably first cultivated in Holland and Denmark. As early as 1484 a discussion of a red currant appeared in a German publication and during the sixteenth century frequent mention was made of the currants by the herbalists of the times. The first red currants cultivated were doubtless of the species *R. vulgare*. *Ribes petraem* was introduced into cultivation in 1561. *Ribes rubrum* was probably brought under cultivation soon after this. Currants were taken to America in 1629 by settlers and records show that those brought at that time were probably of the red and white forms. The black currant was introduced later evidently, though the date is not definitely known. In 1770 plants of three varieties, a black, a red and a white, were offered by a Long Island nurseryman. The list of varieties has grown and there are in America at present

about two hundred recognized varieties. The red varieties have been derived from the three red-fruited species mentioned. Some are pure species but the majority are probably hybrids. The white-fruited varieties have probably come from both *R. vulgare* and *R. rubrum*. Several named varieties of the ornamental species have been introduced but the best known variety in this group is Crandall, which was introduced in 1888 by R. W. Crandall of Newton, Kansas. Varieties of these species have not become popular owing chiefly to their shyness in bearing and to the inferior quality of the fruit.

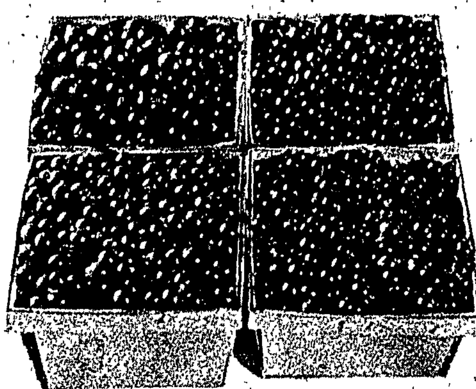

FIG. 40.—CURRANTS IN BERRY-BOXES

Upper left, Climax; Upper right, *R. floridum*; lower left, red-fruited *R. aureum*; lower right, black-fruited *R. aureum*.

Improvement work on *Ribes americanum* has been attempted. Professor N. E. Hansen, Brookings, South Dakota, has grown many thousands of seedlings of this species and lists among his plant introductions several selections under name. These are not being grown widely at the present time, however.

Attention is being turned to the development of the flowering currants for fruit production. During the series of dry years, from 1930 to 1935, plants of these currants have demonstrated marked ability to withstand drouth despite the popular belief that all currants demand liberal supplies of moisture. Doubtless variation in moisture requirement occurs in this group and it is probable that marked differences in

plants of the flowering currants with respect to drouth resistance will be found. One strain in particular that was brought to the attention of the author not only endured the years of low precipitation in one of the driest areas in Saskatchewan but gave bountiful supplies of fine fruit during that period. This type evidently possesses possibilities and it may give rise to varieties that will be of great value in the prairie sections of the North.

Some attention has been given recently to improving *R. petraem* through selection. One variety of this species that is being grown to some extent in United States under the name of Viking has been found to be immune to European Rust (*Cronartium ribicola*). Seedlings growing under unfavourable conditions in a nursery at the University of Saskatchewan have demonstrated marked drouth resistance and produced a good crop of fruit of very fair quality in 1935.

CLASSES

Garden currants fall naturally into three groups on the basis of colour of the matured fruit. These are: black, red and white—and these are the colours, respectively, of the fruit of the three classes. The plants of the common red and the white forms are very similar, belonging to the same botanical species, and are identical as far as fruiting habits are concerned. The common black form is a distinct botanical species and in its fruiting habit it differs from the red and white forms. Other black and red forms that are grown to some extent are of a species of ornamental currant with large showy yellow flowers to which reference has been made above. As already noted the fruits of these are less desirable than the fruits of the common black and common red but are of very fair quality.

VARIETIES

Black.—Climax, Naples, Lee, Collin's Prolific, Kerry, Saunders, Boskoop Giant, Black Victoria, Buddenborg and Magnus. Crandall is a named variety of one of the ornamental species mentioned above. Plants of unnamed forms of the ornamental currants also may be grown.

Red.—Raby Castle, Red Dutch, Fay, Cherry, Red Grape, Perfection, Red Cross, London Market, Diploma, Red Victoria, Long Bunch Holland, Stewart and Prince Albert.

Long Bunch Holland and Prince Albert are late in flowering and in ripening their fruit and show strongly the characteristics of *R. petraem.* They are undoubtedly hybrids involving this species.

White.—White Grape, White Cherry, White Transparent and Large White.

Other varieties have proved satisfactory and might be listed, but those mentioned are at least among the best varieties for prairie conditions. Red Lake is a promising new variety of red currant that is under test in prairie regions.

Propagation

By Cuttings.—The usual method of propagating the currants is by cuttings. The cuttings should be taken in the autumn as soon as the wood is mature and should be made from wood produced during the previous summer. The wood is usually sufficiently mature for this purpose early in October and if possible they should be made at this time. These cuttings should be made from eight to nine inches long and, if practicable, one-half inch of wood should be left above the uppermost bud in each cutting. The cuttings are usually tied in small bundles and are buried at once in moist, well-drained soil out of doors three or four inches below the ground surface. Early in the spring these cuttings are taken up and are planted four to six inches apart in a row in the garden. In a short time, many of these cuttings will produce roots and shoots. The resulting plants are left in this row either one or two years, depending upon the size attained the first year.

By Layering.—Garden currants may be propagated by layering. This is done in the spring and low-lying branches with at least some wood of the previous season's growth are selected for this purpose. Near the base of the one-year-old portion and on its lower surface an incision is made. This incision is made crosswise of the stem and about half-way through the stem. This portion of the branch is then brought in close contact with the soil and is held there by means of a stake or by some other convenient means. Moist soil is then used as a covering for the section a few inches below and above the incision. This soil should be applied to the depth of four to five inches at least and this must be kept moist throughout the season. The tip of the branch must be left uncovered. During the growing season roots are produced at the incision and at the base of the portion of the branch above the in-

cision. Early and before growth begins the following spring—one year after the layer was made—the bank of soil is removed carefully and the new plant is severed from the parent plant. The incision made the previous year may in some cases merely be continued until the stem is cut through. A new plant with roots and capable of independent existence is thus obtained and this plant is planted either in a temporary location or in a permanent location as conditions warrant. The better plan under average conditions is probably that of growing such plants a foot or a foot and one-half apart in the row for one year and at the end of this period transplanting them to the permanent location.

By Seed.—Currants may be propagated by seed. Seedlings do not come true to variety, however, and the chief value of this method is in the production of new varieties. The seeds are separated from the flesh and are spread out to dry. Drying does not appear to lower the germination of seeds of this group of plants and they may be stored for a long period in a dry condition.

Untreated seeds of the currants do not germinate readily. Alternating high and low temperatures after sowing for a period of one to three months are required to bring about the changes in the seed necessary for germination. Temperatures between 75° F. and 80° F. during the day and near 50° F. during the night have been found very effective in bringing about these changes. The seeds are sown in soil in a box about two months before germination is desired and the soil is never allowed to become dry. This box is kept in a warm room during the day and in a cool room or basement during the night. About one month after the treatment is begun seeds will begin to germinate and germination will continue for some time if the alternating temperatures are continued.

The best time to germinate currant seeds is early in the spring. The necessary pre-germination treatment can be given easily during the winter and a long season of growth may be obtained before autumn.

The seedlings should not be allowed to remain crowded in the box too long. Soon after most of the seeds have germinated the transplanting should be done. The young plants may be transplanted to other boxes and each plant should have in its new container an area at least two inches square. In these boxes the seedlings may be grown until autumn. At that time they are removed from the boxes and heeled-in for planting in a row in the open the following spring.

Nursery Stock

Only vigorous, well-rooted stock should be used. One-year-old plants are preferable to those older, as the younger plants are usually more easily handled than older plants, and when being purchased they are less costly. Two-year-old or three-year-old plants may be used, however, if they are given careful treatment.

Plants for the plantation may be grown at home or they may be obtained from a nurseryman. Many growers obtain their plants through the use of one of the methods outlined in the section on propagation.

Soil and Site

Plants of the currants thrive well in a cool, moist, well-drained, rich, clay-loam soil. Soils of other types may be used when necessary, provided organic matter and moisture are at least reasonably abundant.

A good site is as important for the currants as it is for other fruits. A well-sheltered location is essential and protection on the north, west and south sides should be provided. Plants of these fruits may be grown without protection but the results obtained from plants growing under such conditions are far from satisfactory. Good drainage is important and the areas that become flooded during wet periods should be avoided. A northern slope is preferable to a southern slope but a southern slope may be used, in case of necessity. Protection from the winds and good drainage should not be overlooked when one is choosing a site for the plantation.

Planting

As in other fruits the planting should be done early in the spring. Plants of the currants are among the first woody plants to begin growing in the spring and it is very important that the planting be done before appreciable growth has taken place. The usual precautions necessary in the transplanting of bushes and trees should be taken. The holes should be made large enough to accommodate the roots without crowding and should be made deeper than is necessary. The surface soil and subsoil should be kept separate and the surface soil should be used in filling the hole. Enough of this soil should be placed in the hole before the plant is set to bring the crown of the plant to a point about one inch

lower than it was formerly. The soil should be well firmed around the roots of the plant and the top layer should be left loose to serve as a mulch. If the soil is inclined to be dry, a thorough watering should be given after the roots have been covered with soil and before the hole has been filled.

Where conditions will permit it, plants of the currant should be set six feet apart each way. This spacing may appear to be excessive but it should be used where it is possible to do so.

Immediately after being planted the young bushes should be cut back severely. This assists in restoring the balance maintained by Nature and ensures the branching near the ground that is so desirable in these fruits. If the stem of the plant is unbranched cutting-back to within two inches of the ground surface should be practised. If the plant is branched the cutting-back need not be so severe but the branches in this case should be cut back to within two inches of their bases. The proper treatment is illustrated in Fig. 41.

Culture

Plants of the currants require a generous supply of moisture and the plantation should be kept free from grass and weeds. Clean cultivation throughout the season is desirable practice and where the soil is reasonably moist this will give good results. Where the land is likely to become dry before the end of the growing season, the practice of mulching in the spring and cultivating only late in the season may be preferable. Clean straw makes a suitable mulch and this should be applied early in May to a depth of four to six inches or more. Soon after the fruiting season is over the mulch should be removed and frequent cultivations given until autumn. An application of well-rotted manure should be given every spring or every second spring at the most and this worked into the soil around the plants. Such an application will tend to increase the vigour of the plants and will stimulate fruit production. Where barnyard manure is not available commercial fertilizer, as recommended for the red raspberry, should be used.

Pruning and Training

The aim in pruning and training plants of those fruits is to keep the plants shapely and supplied with fruiting wood. The bush form is preferable to the tree form and all plants should be trained to make a low open bush.

Pruning Young Plants.—Proper pruning early in the life of the plant is very important. This early pruning will determine the future shape of the bush and an attempt should be made during this period to distribute the branches well and to train the plant to the desired shape.

The first pruning is given at planting time. As stated above, this consists in cutting-back the plant severely. From the bases of the branches left new shoots arise during the first season and these in turn are cut back severely at the end of the first year as illustrated in Fig. 41. This is to induce

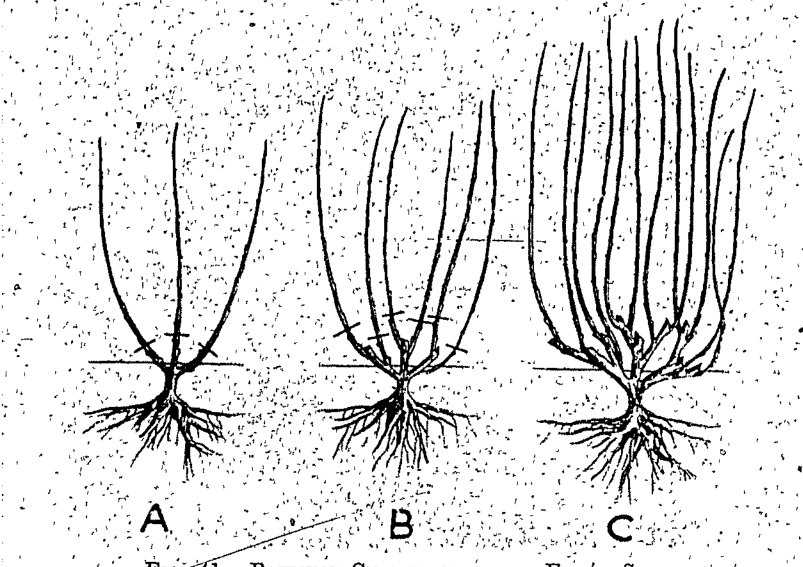

FIG. 41.—PRUNING CURRANTS IN THE EARLY STAGES.

A newly set plant is shown at A. The branches should be cut back to cross-lines. The same plant one year later is shown at B. It should be cut back to cross-lines at this time. At C the same plant is shown two years after planting.

further branching. By the end of the second year the bush will have taken shape and future pruning should be with a view to inducing the maximum fruit production.

Fruiting Habits.—The system of pruning fruiting plants depends upon the fruiting habits of the plant. In the black currant much of the fruit is borne on shoots produced the previous year, while in the red and white currants fruit is not ordinarily borne on shoots under two years of age. The best fruit is borne on one- and two-year-old wood in the black currant and on two- and three-year-old wood in the red and

white currants. Most of the fruit is borne on short spurs. If the plants are to fruit well it is important, therefore, to have a large supply of strong one-year-old and two-year-old shoots in fruiting plants of the black currant and a supply of two- and three-year-old wood in fruiting plants of the red and white currants.

Method of Pruning Fruiting Plants.—Pruning of fruiting plants consists in removing the old shoots and in thinning the new. The older wood should be removed as conditions permit it and enough of the younger shoots left to replace the older shoots and to produce the fruit. From ten to twelve main shoots should be present after the pruning has been completed. In the red and white currants from three to four shoots that have passed the third year will be removed each year and from three to four new shoots left to take their places. The plant will thus have, after the pruning has been completed, from three to four one-year-old shoots, from three to four two-year-old shoots, and a similar number of three-year-old shoots. In the black currant from five to six shoots that have passed the second year will be removed each year and a similar number of new shoots left to take their places. Each plant of the black currant will thus have from five to six one-year-old shoots and from five to six two-year-old shoots. The bushes should be kept open in order that the air may circulate around the leaves and fruit freely, and in order that sunshine may reach every branch. Pruning in the currant is, therefore, a process of renewal. The old wood, wood that has passed the period of greatest usefulness, is removed and new wood is allowed to take its place.

Time of Pruning.—The proper time to prune currants is early in the spring. Wounds made at this time of the year heal quickly and undue drying of the exposed inner tissues will not take place. Further, the new shoots that are to replace those that have passed their period of usefulness are produced early in the season and when the pruning is done in the spring before growth begins these new shoots will be stronger than they would be otherwise and crowding is avoided.

Winter Protection

Further protection against low temperatures than that offered by a shelter-belt is unnecessary in this climate for plants of the currants. Being hardy by nature these fruits seldom suffer from winter injury. Occasionally when an unusually moist season has not permitted the wood to ripen

well before the advent of winter, plants of the black currant suffer some killing, but it is doubtful that the use of a protective measure would be worth while even if such killing were expected.

Duration of the Plantation

If the plants are well cared for a plantation of currants will last many years. Eight or ten crops of fruit or more may be harvested, provided the plants are kept in a vigorous condition. As soon as the plants show a falling-off in vigour and productiveness a new plantation should be started.

Insect Pests

Currant Plant-louse (Myzus ribis).—This is a small greenish insect that appears early in the spring and causes considerable damage to the foliage. The leaves attacked become curled and distorted, as shown in Fig. 42, and the upper surface becomes reddish in colour. Badly infested plants may lose their leaves and may fail to mature their fruit. The insect passes the winter in the egg stage on the branches near the buds and these eggs hatch in the spring about the time the buds are opening.

This pest can be controlled by spraying the plants, soon after the buds open and while the leaves are very small, either with a tobacco solution or with a soap solution. The former is the better and the best-known standard tobacco product of known strength on the market is "Black Leaf 40". This material may be obtained from seedsmen and from some it may be obtained in small quantities. This is diluted with water and one part of the compound is used with six hundred to eight hundred parts of water. The addition of a small amount of soap to the tobacco solution increases the efficiency of the latter, as noted in the chapter on insecticides and fungicides, and is recommended. If the soap is to be used alone the solution should be made up by dissolving one ounce of good laundry soap such as Ivory in one quart or one and one-half quarts of hot soft water. The solution should be allowed to cool before being applied. The application must be made in such a way that the entire body of every insect is covered with the solution. These solutions kill by contact and any insect that is not reached with the solution will not be injured by the spray. If for some reason the early application has been omitted, an application may be made later. If the application is made later, when the leaves are large, the

solution must be applied to the under-surface of the leaf. It is on the lower surface of the leaf where the insects are found during the season and the necessity for reaching the under-surface of the leaf with the spray is evident. When spraying is done just after the buds have opened, every part of the plant can be reached readily with the spray and if possible the spraying should be done at that time.

Imported Currant-worm (Pteronus ribesii).—This is a small greenish-coloured worm that eats the leaves of the plant. The adult is a saw-fly, and the female lays her eggs in May on the under-surface of the leaf and usually on the midrib. These eggs soon hatch and, being very small, at first the larvae pass unnoticed for a short time. They usually become conspicuous toward the end of May and some may be present during much of June. If many are present, the plant may be completely defoliated and the fruit will fail to develop normally. The plants are much weakened by such defoliation, and if control measures are not applied, the plant will eventually die from exhaustion.

As soon as the pest is seen at work the infested parts should be dusted lightly either with Paris green or with lead arsenate, or with calcium arsenate mixed with flour, one part of the arsenical with fifteen to twenty parts of flour. After the fruit has become two-thirds grown it is unsafe to use these remedies, and if control measures are necessary after this time the infested parts of the plants should be dusted with hellebore. For application this agent may be mixed with flour, one part of the agent to two parts of flour. This substance loses its poisonous property in a short time when exposed to the air and must be kept in air-tight containers when not being used. An application of this remedy can be made to infested plants, with perfect safety, two or three days before the fruit is to be harvested.

If spraying is preferred to dusting, these agents may be applied as sprays. The strength at which each should be used is given in the chapter on insecticides and fungicides.

Tent-caterpillars.—Different forms of tent-caterpillars are found in the Canadian West but the one usually present on currants and the gooseberry builds a distinct web. This web increases in size as the caterpillars increase in size and the season advances. Eventually the web may become very large and much of the plant may become involved. The pest is usually found within the web during the warmest part of the day.

Tent-caterpillars pass the winter in the egg stage. These

eggs are laid in masses and these masses more or less encircle the stem. The eggs hatch about the time the buds open and the tiny larvae begin their work without delay. The first injury is thus done early in the season.

The best control measure for this pest is that of removing and burning the twig or branch on which the web is found without delay. If this is done during the warmest part of the day, all the caterpillars of the colony will be in the nest and will be destroyed. Where the removal of a branch is objection-

FIG. 42.—PLANT-LOUSE ON CURRANTS

Leaves on the twigs to the left are infested while those on the twig to the right are free from the pest.

able or where the nest is small, the web with its contents can be removed by hand and either burned or crushed beneath the foot.

For control of the form that does not build a large web spraying or dusting with an arsenical may be resorted to. In this case the treatment recommended is that outlined for the control of the Imported Currant-worm, where a compound of arsenic is to be used.

Yellow Currant Fruit-fly (Epochra canadensis).—The injury is done by the larva which is small and of a creamy colour. It attacks the fruits of the currants and gooseberry. If the infested fruits are examined, one maggot or more will be

found feeding on the pulp and the seeds. The adult is a two-winged fly smaller than the house-fly, that appears about the close of the flowering period of the plants of these fruits. A week or ten days later the females puncture the skin of the tiny fruits and lay their eggs in the flesh below the skin. These eggs hatch and give rise to the maggots that are frequently found present. Infested fruit colours prematurely. Much of this fruit drops to the ground after colouring and before the fruit that is not infested matures.

This pest is very difficult to control. It is obvious that nothing can be done to prevent injury after the eggs are deposited in the fruits. A measure that is to be effective must result in the destruction of the females before egg-laying commences. The adults are very fond of sugary substances and may be destroyed readily through the use of a poisoned bait. If it is to be effective this measure must be applied before the females reach the egg-laying stage. The measure consists of spraying currants, gooseberries and other plants in the immediate vicinity with a mixture of lead arsenate, water and molasses. To ten gallons of water, one-half pound of arsenate of lead powder and one quart of cheap molasses are added. This mixture should be applied with sufficient pressure to give a fine spray. The first application should be made soon after the blossoms fall. A second application should be made a week later and a third application a week later than the second. The molasses is used as a sweetener and for the purpose of attracting the flies. It is important that the application be made at the proper time and that all plants in the immediate vicinity of the currant and gooseberry plantation be sprayed. While this treatment may not give one hundred per cent control, it is well worthy of a trial and experience shows that it will reduce greatly the percentage of infested fruit. If arsenate of lead is not obtainable calcium arsenate may be used.

The plan of plucking the fruit and burning it, as is sometimes recommended, will not destroy all the pests though it should reduce the number for the following year. By the time the pest is found present some of the grubs will have left the fruit and will have entered the ground. This measure might be used, however, in combination with the one outlined above.

DISEASES

Gooseberry Mildew (*caused by* Sphaerotheca mors-uvae).—This disease occurs on the currant as well as on the goose-

berry and is usually characterized by a mouldy growth on the leaves. Late in the season the leaves may take on a brownish colour and may drop to the ground. In some cases the twigs and tho fruit also are attacked.

This disease yields readily to proper control measures in ordinary seasons. In wet seasons it is difficult to keep under subjection but if the treatment recommended is given at the proper time at least fair results will be obtained. All plants that are likely to be attacked should be sprayed with a sulphur solution. One of these is made by dissolving one ounce of liver of sulphur (potassium sulphide) in two gallons of water. The first application should be made just before the buds burst; the second, just before the flowers open and additional applications at intervals of ten days until four or five have been given. A more effective spray is made by dissolving soluble sulphur or "Dry lime-sulphur" in water. For the first spray, which is given just before the buds open, a solution made by dissolving one pound of soluble sulphur in four gallons of water is used, and the later sprays are made by dissolving one pound of the compound in fifteen gallons of water. The times of application with this spray are the same as those where liver of sulphur is used. When soluble sulphur is used further spraying for Mycosphaerella Leaf-spot and Anthracnose is not necessary.

Mycosphaerella Leaf-spot and Anthracnose (caused by Mycosphaerella grossulariae *and* Pseudopezisa ribis, *respectively)*.—These are two diseases found attacking leaves of the currants in the North and considerable damage results at times. The diseases are manifested on the leaves by the presence of numerous brown spots. Affected leaves usually turn yellow and fall prematurely. Anthracnose may attack other parts, notably the fruits. The spots on the fruits are small, resembling fly specks, and affected fruits fail to develop normally. These two diseases are somewhat similar in general appearance and while one familiar with the diseases can usually identify them without the aid of a microscope, the use of such an instrument may be necessary in some cases.

Where these diseases are destructive, control is effected through the use of a sulphur spray. Soluble sulphur or "Dry lime-sulphur" is effective and this is used at the rate of one pound of the agent to four gallons of water for the first spray and at the rate of one pound to fifteen gallons of water for the later sprays. The first application should be made just before the leaves unfold, the second application just before the flower-buds open, the third soon after the petals fall and

an additional application about ten days after the third. Merely dusting the plants with finely ground sulphur at the times recommended for spraying has given satisfactory control. The spraying schedule recommended for the control of mildew is satisfactory for leaf-spot and Anthracnose, and where soluble sulphur is used one set of sprayings will control all three diseases.

CHAPTER XII

THE GOOSEBERRY

THOUGH of less importance than some of the other hardy fruits grown in northern sections, the gooseberry has a place in the prairie fruit garden. To many people it is a favourite fruit and for certain purposes it is unexcelled. Very fair yields may be obtained from a small area and, where space will permit it, a few plants at least should be grown.

BOTANY

The gooseberry belongs to the genus *Ribes*, as do the currants. The plants are woody perennials with erect or procumbent stems. Spines and prickles are found distributed along the stem in nearly all gooseberries and in most forms and varieties these are very prominent. The flowers are similar to those of the currants and the fruit is of the same type but is usually larger.

Cultivated gooseberries have been derived chiefly from *Ribes grossularia*, an Old World species, and *Ribes oxyacanthoides*, an American species which is found as far north as the Arctic Circle in western Canada. The fruit of the former is large and hairy and is red, greenish or yellowish in colour, while the fruit of the latter is small and smooth and is reddish in colour. Plants of *R. grossularia* are relatively tender and are not hardy in western Canada while those of *R. oxyacanthoides* are sufficiently hardy to winter well in Nature even in the most northerly settled districts of the prairie provinces. Plants of the former species are very subject to mildew while those of the latter species resist this disease well. Much hybridization between these two species has been done and many of the varieties grown at present are hybrids involving these two species.

Three species native to the Great Plains region and of some importance are *Ribes missouriensis*, *Ribes cynosbati* and *Ribes setosum*. The first species is found only in the southern section of this region while the others occur farther north. The plant of *R. missouriensis* is a tall bush reaching a height of six to seven feet and producing few but stout spines. The fruit is borne in small clusters on long stems and is almost

black at maturity. The plants of *R. cynosbati* and *R. setosum* often reach a height of from three to four feet. The branches of the former are smooth or nearly so while those of the latter are bristly. The fruit of the former is red at maturity and bears prickles. That of the latter is red to black at maturity and varies from smooth to somewhat bristly.

DEVELOPMENT

Gooseberry in Europe.—The European gooseberry was probably first grown as a garden plant in northern Europe. It is not known definitely in which country it was first grown, but it was considered a valuable fruit in English gardens during the sixteenth century. The first English writer to mention the gooseberry was Turner who made reference to it in 1548. In 1629 Parkinson described five varieties; in 1778 Mawe described twenty-four varieties and in 1825 the London Horticultural Society listed one hundred and eighty-five varieties. This number has increased to several hundred at the present day.

Gooseberry in America.—This gooseberry was brought to America by early settlers probably during the seventeenth or eighteenth century. Climatic conditions west of the Atlantic did not meet its requirements, however, and a native mildew to which it was very subject made its successful culture on this continent extremely difficult. With the discovery at a later date of control measures for this disease interest in this gooseberry by Americans was renewed, but it has never become in the New World an important fruit commercially. Even though many varieties are grown in Europe very few are found in American plantations. The greatest value of the European gooseberry to American fruit growing has been in its ability to hybridize with the American species and to transmit to the progeny resulting some of its good qualities.

According to Hedrick no pure-bred derivative of the *R. oxyacanthoides* has come into prominence and remained. The first variety to be derived from this American species was Houghton which was first recorded in 1847. In 1855 Downing, a seedling of Houghton, was introduced. Both varieties are regarded as hybrids between the American species and the European species. For seventy-five years Houghton and Downing were widely grown but with the introduction of superior varieties they have been grown less and less excepting in northern latitudes, where only the hardiest varieties survive the winters. Many varieties involving American

species have been introduced during the past fifty years, and certain of these represent a large percentage of the gooseberries produced in America at the present time. One variety, Oregon or Oregon Champion, is of special interest as it has been prominent among varieties used in the breeding of hardy gooseberries for northern sections. This variety originated in 1860 by Dr. P. Prettyman of Multonomah County, Oregon, and resulted from a cross between Crown Bob, a European variety, and Houghton. Varieties, the

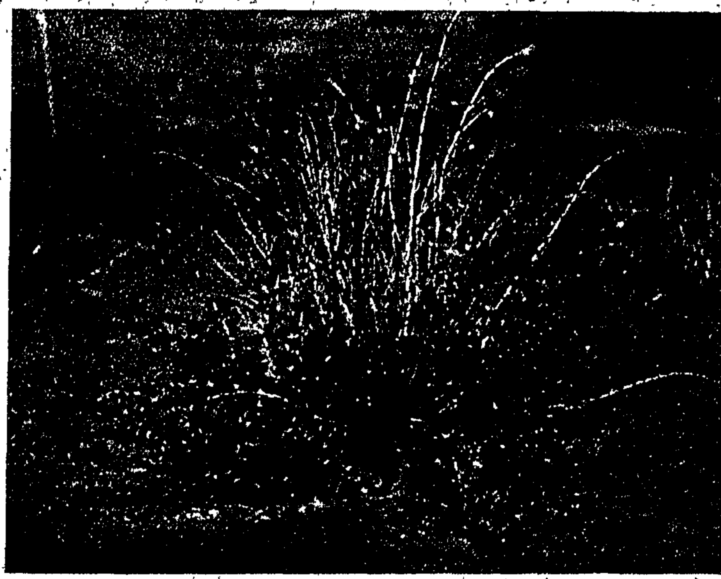

FIG. 43.—PLANT OF CHAMPION GOOSEBERRY

This photograph was taken during the flowering season of 1936 and shows the severe killing back that occurred during the winter of 1935–36.

plants of which were reputed to be free or almost free from spines and prickles, have been introduced, but in some cases at least spines and prickles developed when a new environment was given.

Gooseberry in Great Plains Region.—Definite attempts have been made to develop varieties of high quality and with sufficient hardiness for the Great Plains region. Extensive work has been done at the Minnesota, South Dakota and North Dakota agricultural experiment stations. Varieties have been introduced from all three stations, and these appear to have a place among the fruits for this region.

Varieties that have been developed at the North Dakota station appear the most promising for the most northerly sections. Breeding in the gooseberry was begun at this station in 1920. The native species, *R. setosum* and *R. missouriensis*, were hybridized with the cultivated varieties, Champion, Transparent, Houghton, Downing, Copland, Josselyn and Carrie. A total of five hundred and thirty-three seedlings were grown. Those resulting from the hybridization of Oregon Champion with *R. missouriensis* were outstanding and all the other seedlings were discarded. Fourteen of these were considered sufficiently good to propagate and to test further. Only three, however, have been given the seal of approval and these were named and released in 1932.

Increase in Size through Selection.—An excellent demonstration of the value of selection is found in the European gooseberry. Fruits of the wild form weigh about one hundred and twenty grains each. In 1786 gooseberries weighing two hundred and forty grains were exhibited. As time went an increase in size was noted and in 1852 fruit of the variety London was found to weigh eight hundred and ninety-six grains.

Classes

Cultivated gooseberries are usually divided into two classes on the basis of origin. One class of varieties is usually designated as the European and the other class as American. As is stated above there is no pure-bred American variety of importance and the varieties that are classed as such are hybrids between the European and American species. Plants of the European varieties are relatively tender while those of most of the hybrid varieties are relatively hardy. Very large fruit and extreme hardiness appear not to be found together in the gooseberry and the fruits of the hybrid varieties are smaller and somewhat inferior in quality to those of European varieties. Plants of European varieties appear to be too tender for northern sections and plantings of the gooseberry in this region should be confined for the present to varieties in the hybrid class.

Varieties

As in other fruits, varieties in the gooseberry differ with respect to hardiness, size and quality. While hardiness is a prime requisite, as much size and as much quality as possible should be obtained with the necessary hardiness when a

selection of varieties is being made. Varieties that can be grown successfully in the North and that are satisfactory in fair measure at least are listed below.

Houghton.—This variety is one of the hardiest gooseberries under cultivation. The plant is moderately vigorous and is very productive. The fruit is small to medium in size with a thin skin, is red in colour and is of good quality. Owing to the presence of many spines and to the extreme shortness of the stems of the berries the harvesting of this fruit is somewhat difficult. It originated from seed sown in 1833 by Abel Houghton, Lynn, Massachusetts, and was named some years later.

Oregon Champion.—The plant of this variety is productive but is moderately hardy only. Some killing-back usually occurs each winter and in some cases it is severe. The fruit is above medium size for the class, is green in colour when mature, has a thin skin and is of excellent quality. While present, the spines are not very troublesome and the fruit can be harvested readily. This is probably the best variety that can be recommended at the present time for the prairie fruit plantation that is well sheltered. This is from a cross between Crown Bob and Houghton and was originated about 1860 by Dr. P. Prettyman, Multonomah County, Oregon.

Downing.—While slightly less hardy than Champion this variety may be grown successfully in locations that are well protected. The plant is productive and the fruit is above medium size, light green in colour and of good quality. The fruit is not as easily harvested as that of Champion. This variety was originated by Charles Downing, Newburgh, New York, in 1855, and is a seedling of Houghton.

Other varieties have been tried at the University of Saskatchewan but with little success. In all cases the plants lack the hardiness that is necessary for the severe climate of the North. Some of these varieties are Carrie, Josselyn, Pearl, Charles, Smith's Improved, Transparent, Como, Mabel, Clark, Poorman, Fredonia and Silvia. In favoured locations in the extreme southern parts of the prairie provinces some of these varieties could probably be grown moderately successfully.

Three varieties introduced by the North Dakota Agricultural Experimental Station, Fargo, hold considerable promise for the North. Lack of information prevents the definite recommendation of them for culture in the most northerly sections as yet but their behaviour when grown beside Champion and Downing at Fargo gives indication

that all three are likely to have an important place among gooseberries for the coldest fruit-growing sections. Plants of fair size of all three varieties came through the winter of 1935–36 in the University Plantation with very little killing-back while plants of Houghton suffered severe injury. This proved to be a test winter for fruits and there remains little doubt that these varieties have a place in gardens in the prairie provinces.

The descriptions of these varieties given below are taken from Bulletin No. 267 of the North Dakota Agricultural Experiment Station:

"Pixwell has been about fifty per cent more productive than Carrie; the oval berries are about twice as large, are an attractive translucent light green colour when immature, ripening to pink. The plant carries few thorns; the canes are rather slender and somewhat drooping on older plants. It is the abundance of fruits which hangs away from the stems making it easy to pick that gives it its name Pixwell. This variety compared to twenty others has ranked at or near the top in all cooking tests for jelly, preserves and sauce. It is characterized by having a thin skin.

"Abundance gets its name from its enormous productivity. Its crop has averaged twice that of Carrie. The fruit is about the same size as Pixwell but is round and dark green when immature, turning to purplish when ripe. The bush is more thorny than Pixwell but its productivity and long stems make it easy to harvest. The cooking quality, while not equal to Pixwell, is very good, particularly for jelly. When fully mature the skin is rather tough.

"Perry. The fruit of this variety is similar to Pixwell. The most striking characteristic of the variety is the extremely vigorous and upright growth of the plants which often reach a height of more than five feet without support. For this reason the harvesting is easy. One need not stoop to get the fruit. It has been about as productive as Pixwell. Cooking tests place it but little below Pixwell for culinary purposes, though the skin is tougher when the fruit is mature."

A very good variety of gooseberry, the identity of which has been lost, has done well at Indian Head, Saskatchewan. The original plants were obtained by Mrs. Davidson of this town many years ago and the variety name forgotten. The plants thrived in her garden and produced great quantities of very large luscious berries. Layers were supplied to friends that had seen the plants in fruit and that were desirous of obtaining plants, and propagation of the variety began. At

Saskatoon, the plants show some killing-back, but they evidently possess considerable hardiness. The fruit is much larger than that of Champion and is said to be of good quality. It is expected that the variety will be identified in the near future, but until then it will be known as Davidson. There is a possibility that this variety will have a prominent place among gooseberries for the far north.

Mr. R. W. Wilson, Assistant Superintendent, Experimental Station, Indian Head, Saskatchewan, writes concerning this

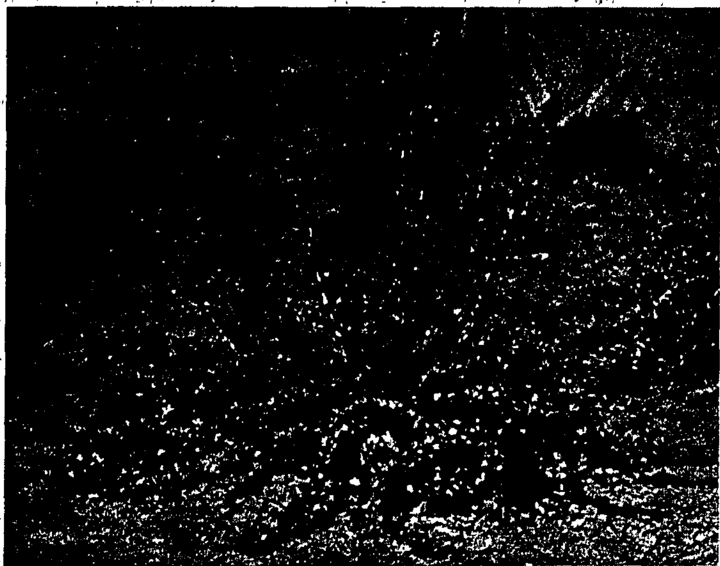

FIG. 44.—PLANT OF ABUNDANCE GOOSEBERRY

This, too, was taken during the blooming season of 1936. Note that the branches are leafing-out to the tips.

gooseberry as follows: "The Davidson gooseberry has been grown at Indian Head for the past thirty-six years, having been introduced in 1900 by Mrs. A. Davidson from the district of Garafraxa, Ontario, where it had grown previously. It has been grown under test at the Experimental Farm here for many years and has proved to be sufficiently hardy and large-fruited, seeming to thrive in dry years. It appears to be highly resistant to most diseases. The fruit is a rich golden yellow when ripe, quite sweet and of excellent quality for cooking purposes. Specimens of fruit have been almost one and one-half inches long and one inch through.

"The Davidson gooseberry should be a valuable acquisition to the fruit list for the prairies and no doubt will be favourably received when better known."

PROPAGATION

The gooseberry may be propagated either by cuttings or by layers. Where propagation by cuttings is adopted, the method is similar to that described above for currants. The results obtained, however, are usually less satisfactory than those obtained with currants because gooseberry cuttings do not root as readily as do currant cuttings. The cuttings of some varieties, however, root more readily than do the cuttings of other varieties and this method may be used to advantage in some cases.

The more satisfactory method of propagating the gooseberry is by layering. A special form, known as mound layering, is used. Bushy plants are selected for propagation, and these are cut back to within four to six inches of the ground level in the spring before growth begins. This treatment results in the production of many new shoots which arise from the bases of the stems cut back. After these shoots have reached the height of six inches mounding is practised. Moist earth is placed over the base of the bush and is banked around the lower portions of the new shoots. This soil is firmed reasonably well. As the shoots increase in length the mound is made larger until the lower half of the full-grown shoot is covered. This bank of soil must be kept moist throughout the season. If the soil is kept moist the shoots will send out roots and by autumn each shoot will have a well-developed root system. Late in the autumn these mounds should be well covered with straw to prevent injury to the young roots during the winter months. As early as possible the following spring the earth is carefully removed from around the shoots and the rooted shoots are detached from the parent plant. Each shoot with its roots constitutes a young plant and should be planted before the roots become dry. The usual method is that of growing the young plants in a nursery row for one year or more. Accordingly the plants are set about six inches to one foot apart in a row in the garden and are grown there until they are ready to be moved to the permanent location. If, at the end of one year, they are large enough for the permanent location these plants are transplanted at this time, but if not they are left undisturbed until the spring following.

Where only small increase is desired common layering may be used to advantage. A few of the branches of a plant are brought in contact with the ground and are covered over part of their length with moist soil. The tips of the branches must be left exposed. Sufficient soil should be used to cover well the portion of the branch to be in contact with the ground and this soil must be kept moist throughout the growing season. By autumn, roots will have formed on the covered portion. These rooted branches are left undisturbed until early the following spring at which time they are removed from the parent plant and set in the nursery row.

Nursery Stock

It is important to use strong well-rooted plants. Such plants should be either one year or two years from the layer and should have three branches at least. Plants from cuttings should be two years old.

Soil and Site

Conditions that suit the currants suit the gooseberry also. Plants of this fruit delight in a cool soil that is naturally moist, and one of the heavier types is preferable to one that is very light. Good surface drainage is important, however. The gooseberry responds well to fertilization and a soil high in fertility is desirable.

Shelter is very necessary for cultivated gooseberries. Most of the recommended varieties are either not fully hardy or barely hardy even with shelter and the use of such varieties on an area that is not well protected from winds usually results in failure. A southern slope should be avoided if possible as the plants normally begin growth early in the spring and the extra heat received on such a slope may be sufficient to induce blooming before the last heavy spring frost occurs.

Planting

Plants of the gooseberry should be planted very early in the spring. The gooseberry normally leafs out considerably earlier than most other plants, and it is important to set the plants out before this stage is reached. The planting should be done in April in ordinary years if possible.

Being smaller than those of the currants, plants of the gooseberry may be set five feet apart in the row. Where more

than one row is to be planted a distance of six feet should be allowed between the rows.

PRUNING

Pruning in the gooseberry is similar to that in the red and white currants. In the gooseberry some fruit is borne on one-year-old wood but most of it is borne on spurs on two-and three-year-old wood. From eight to ten main branches should

FIG. 45.—BUSH FRUITS DEMAND GOOD SHELTER.
A currant and gooseberry plantation at the University of Saskatchewan is well sheltered by hedges of willow.

remain and these should be well distributed. These should be made up approximately of three one-year-old branches, three two-year-old branches and three three-year-old branches. All branches over three years of age and those in contact with the ground should be removed. A free circulation of air must be allowed and sufficient pruning should be done to maintain an open bush. The pruning should be done in the spring before growth begins.

Pruning in the early stages should be severe. At planting time the branches should be cut back to within two inches of their bases to induce further branching. Similar cutting back

should be practised one year later to give the foundation required for a well-formed and fruitful bush.

Culture

Either clean culture throughout the season or the use of a mulch until the season of harvest and then clean cultivation the remainder of the season may be practised. A light mulch applied in the spring will reduce considerably the heating of the soil by the sun and will reduce greatly evaporation from the soil surface. Since the gooseberry favours a cool soil and demands much moisture the mulching method is preferable. Two or three inches of well-firmed clean straw or of similar material will make a very satisfactory mulch.

Winter Protection

The giving of special winter protection to plants of the gooseberry is practicable in some cases. Being fairly low growing the plants of most varieties can be covered readily. The most convenient covering is clean coarse straw or marsh hay. A small mound of this over each plant will offer much protection. In order that mice may not be attracted to the plants unduly it is advisable to delay the use of the covering until after winter has set in. A handful of poisoned wheat should be distributed around the base of each plant before the covering is used. The plants should be uncovered toward the end of April. The use of soil as a covering is not very practicable owing to the difficulty of removing it in the spring.

The better plan is to grow varieties that will winter at least reasonably well without protection. A sacrifice in quality of fruit with regular cropping is preferable to the possible severe killing-back of the plant and the loss of a crop of fruit the following year.

Life of a Gooseberry Plantation

Gooseberry plants should continue to fruit for many years. At least ten or twelve good crops of fruit can be harvested from a plantation if good cultural treatment is given.

Insect Pests and Diseases

Pests and diseases attacking currants usually attack the gooseberry also. Measures recommended for their control on the currants are recommended for their control on the gooseberry.

CHAPTER XIII

THE GRAPE

THE grape is of minor importance as a fruit for cultivation in the Great Plains region at the present time. In the northern sections of this region it is grown only with considerable difficulty and the varieties that can be made to grow are few in number. Even in the southern sections of this plains area only the hardiest group of varieties can be grown successfully.

BOTANY

The grape belongs to the genus *Vitis*. The flowers are small and greenish. A perfect flower has five petals, five stamens and a two-celled ovary with a pair of ovules in each cell. The fruit is a pulpy berry. The plants climb by tendrils which are borne opposite the alternately arranged leaves. The clusters of flowers and of fruits also are borne opposite the leaves and appear on the new branches of the season. Several species are represented in commercial grapes, and the most important of these are the Fox Grape (*Vitis labrusca*), Summer Grape (*Vitis aestivalis*), Muscadine Grape (*Vitis rotundifolia*), Riverbank Grape (*Vitis vulpina*) and European Grape (*Vitis vinifera*). The first four species are native to America and the last is believed to have had its origin in south-eastern Europe near the Caspian Sea. The European species is the tenderest of the group and *V. vulpina* the hardiest. The range of the latter extends far north into Manitoba and is said to occur where the temperatures drop to $-60°$ F.

The European grape differs markedly from American species. Fruit of the former is relatively high in sugar, has excellent keeping qualities and is grown chiefly for wine production. Fruits of American species are lower in sugar content, have poor keeping qualities and are used chiefly for dessert. American grapes are considered inferior to European grapes but the former are more flavourful and refreshing than the latter. The berries and bunches of most of the European varieties are larger than those of American varieties and the plants of the former are more compact and require less pruning than those of the latter. The European form is very

subject to attacks by the pest known as Grape Phylloxera and is very susceptible to Downy Mildew, Powdery Mildew and Black Rot, while the American forms are relatively free from these enemies.

Different types of flowers are found in the grapes. For convenience these may be classed as (1) staminate, (2) perfect hermaphrodites and (3) imperfect hermaphrodites. These are shown as A, B and C, respectively, in Fig. 46. A purely pistillate type of flower is not known in the grape. A sharp distinction between types of flowers cannot be made, as transi-

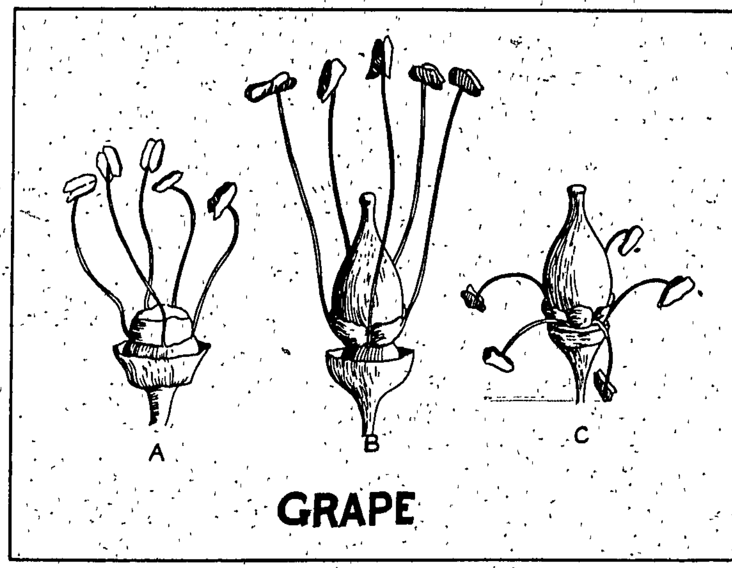

FIG. 46.—FLOWERS OF THE GRAPE

tional forms are numerous. In the staminate group are found those without any trace of a pistil and those with pistils not sufficiently developed to result in the setting of fruit. In the perfect hermaphrodite group are those with upright stamens and with pistils at least sufficiently developed to set fruit when fertilization takes place. The imperfect hermaphrodite group consists of those with hermaphrodite flowers in which only the pistils are functional. In these the stamens may be (*a*) erect but crinkled, (*b*) spreading and slightly recurved and (*c*) markedly recurved or recurved and curled. The stamens in these cases give rise to pollen grains that are more or less shrivelled and are incapable of germination.

Development

The European grape has a long history. It is not known when it was first brought under cultivation but records show that it was cultivated in Egypt between 5000 and 6000 years ago. Varieties were evidently numerous during early periods and many of these were distinctive in their characteristics. Virgil described fifteen varieties and Pliny gave detailed descriptions of ninety varieties that were being cultivated in his time. The grape has been the chief cultivated plant of the Greek and Latin nations and the history of grape development during the early Christian era and down through the Middle Ages to the present day is largely the history of agriculture in southern Europe during that period.

The Grape in America.—The cultivation of the grape in America dates back only a little over three hundred years. Before the settlement of eastern North America progressed far, attempts were made to establish the European grape in the New World. In 1616 a very definite attempt was made by an English company to establish *V. vinifera* in Virginia. This was unsuccessful. Repeated attempts were made during the seventeenth and eighteenth centuries to establish this grape in the eastern United States but these all failed. Attention was turned to native species and the first variety which was believed to be of native species was introduced about 1790. This variety was named Alexander and was derived from *V. labrusca*. Soon after its introduction this variety appeared as the Cape grape. A second variety was introduced in 1802 but it remained unnamed until a few years later when it was designated Catabwa. Isabella, a third variety and another of native species, was introduced soon after Catabwa. These three varieties constituted the foundation of the grape-growing industry in eastern North America and were probably the only important varieties until the middle of the nineteenth century.

The next important step in the development of the grape industry in eastern America was that of hybridizing native species with the Old World species. The first authentic hybrids were made about 1850 or soon after this date. The best known of these were obtained in 1854 by E. S. Rogers of Salem, Massachusetts, and important varieties of these hybrids were introduced under the names Agawam, Lindley, Massasoit, Wilder, Herbert and Barry. This group is frequently referred to as Roger's hybrids. Delaware, a popular

present-day variety, was discovered growing in a garden in New Jersey about this time. This variety is believed to be a hybrid between *V. aestivalis* and *V. vinifera* but its origin is obscure.

In 1840 boys scattered seeds of wild grape on the farm of Ephraim Bull of Concord, Massachusetts. From these seeds a plant was obtained which fruited in 1846. The seeds were taken from the fruits produced and were sown. From one of these seeds the famed Concord variety arose. Introduction took place in 1853. From the beginning the variety was popular and today it is grown more extensively than any other variety in eastern North America. While this variety has long been looked upon as one derived from *V. labrusca* only, cytological evidence to show that it is a hybrid between *V. labrusca* and *V. vinifera* has been presented recently.

During the period from 1853 to the present day many varieties were introduced. The list of recommended varieties either of native species or of hybrids between the native species and the European grape now totals between 500 and 600. While many of these have merit, only a few have become popular.

Development in California.—While the grape-growing industry was becoming established in eastern North America a similar industry was being developed in California. In the latter half of the eighteenth century *V. vinifera* was introduced to this State from Mexico by the Franciscan Missions. For a long time only one variety which was introduced from Mexico was grown, and not until many years after the American occupation of this State and the arrival of immigrants from Europe were other varieties introduced. Conditions there suited this Old World grape and little difficulty was experienced in establishing what has become a very important industry in that State. From some of the many varieties introduced have come our various types of raisins and the popular class of table grapes represented by the varieties Emperor, Tokay and Malaga.

Development in Great Plains Region.—Special attention has been given during recent years to the development of grapes for the Great Plains region. Some progress has been made through the hybridization of *V. vulpina* and varieties of *V. labrusca*. Grapes from Asia have been introduced and these too are being used in the development of grapes of good quality for the North-West. The number of such varieties of value introduced to date is small, however.

VARIETIES

Only the hardiest and earliest maturing varieties have been grown with any degree of success in the prairie provinces of Canada. The varieties being grown with at least some measure of success in certain sections of this region are Alpha, Beta, Dakota, Suelter and Hungarian. All are probably hybrids between *V. vulpina* and *V. labrusca* though the exact origin of some of these is not known. Of the group, Hungarian is the least hardy and Beta is probably the hardiest. The fruit in all these varieties is a decided improvement over that of *V. vulpina* both in size and in quality though it is inferior to that of the less hardy varieties. That of Hungarian is larger and of better quality than that of any of the other varieties mentioned. The fruits of all are bluish-black in colour, are juicy and make a good unfermented drink and very fair preserves.

PROPAGATION

The hardy grapes are usually propagated by cuttings. These cuttings are of the length required to include two buds and are made in the fall from fully matured shoots of the current season's growth. The base of the cutting is made just below one bud and the apex a short distance above the other bud. These cuttings are buried a few inches deep in moist soil out of doors immediately after being made and are left there until the following spring. A well-sheltered location should be chosen for the cuttings and a covering of litter should be applied just after winter has set in. In the spring they are taken up and planted about six inches apart in a row at an angle of 30°-45° with the earth's surface and sufficiently deep to bring the top bud just above the ground surface. In this row the plants may be left one or two years depending upon the amount of growth made during the season of planting, and are then planted in their permanent locations.

Propagation by layering is frequently more successful than propagation by cuttings. The canes to be used are held in contact with the ground and are covered with two to three inches of moist soil. This is done in the spring and canes produced the previous year are used. It is well to cut the cane back to three or four joints before the layering is done. The soil in contact with the cane must be kept moist throughout the season. By autumn a new plant will have been produced at each joint. The layers should be well covered just

before winter sets in, as the young roots on the new plants are very tender and are easily destroyed by low temperatures during the winter. In the spring the covering is removed and the layers are lifted and cut into plants. The plants resulting are henceforth treated as individuals.

Propagation of grapes by seed is possible. Named varieties do not come true from seed, however. The seeds evidently require after-ripening for two or three months and the

FIG. 47.—FRUIT OF THE DAKOTA GRAPE

author has obtained good germination with seeds treated in the manner recommended for plum pits.

PRUNING

To fruit well and consistently plants of the grape must be pruned annually. The first pruning is given at planting time and each year thereafter this operation must be repeated to keep the plants supplied with the wood required for heavy fruiting. With the exception of that necessary at planting time all the pruning should be done in the fall before the plants are covered for winter.

Different systems of pruning are used for the grape. The

best-known system is the Kniffen, but this is not suited to use where the plants must be laid down and covered for winter. A system that permits the removal of the vines from the trellis and the placing of them on the ground is outlined below.

Only one stem or cane should be left on the plant at planting time. This should be cut back to a point a short distance beyond the second bud. From the two buds left two stems should develop. A newly set plant correctly pruned is illustrated at A in Fig. 48.

In the autumn of the first year the weaker of the two stems that developed should be removed and the one remaining should be cut back to two buds before the plant is covered. A plant thus pruned is shown at B in Fig. 48. Two shoots should develop from these buds during the following growing season.

The pruning in the fall of the second year is similar to that given in the fall of the first year in that the weaker shoot is removed. The one left should not be cut back as severely this year, however, and should be left two or three feet in length. This would probably carry four or five buds. In the spring of the third year this vine which has been lying on the ground until this time should be lifted, placed parallel to the bottom wire and tied to it. A plant pruned in the fall of this year is shown at C and the same plant tied to the first wire the following spring is shown at D. The shoots developing from the buds remaining should be tied in vertical positions, as they elongate, to the second and third wires.

In the fall of the third year all the upright shoots excepting the last one are cut back to two buds. The base of such a shoot that has been cut back will be referred to as a spur. The last shoot is removed from the second and third wires and is placed horizontally on the first wire to lengthen the trunk of the plant. This shoot should be cut back far enough to leave a trunk with a total length of six to eight feet. The condition obtaining after this pruning is done is shown in E. From the buds on the spurs and the buds on the trunk extension, shoots develop the following year and these should be tied, as they develop, to the wires above. The condition obtaining in the autumn of the fourth year is shown at F. All the vertical shoots should be removed at the points indicated by the short cross-lines. The shoots from the spurs are each cut back to one bud.

The condition obtaining at the end of the season of the fifth year is shown in G. The short cross-lines indicate the

points at which the shoots should be removed in the fall of this year. All the shoots are cut back to one bud. Treatment in the autumn of each subsequent year is the same as that in the autumn of the fifth year.

This system involves the frequent tying of developing shoots. These shoots must be tied as they develop to the horizontal wires and such attention should be given at

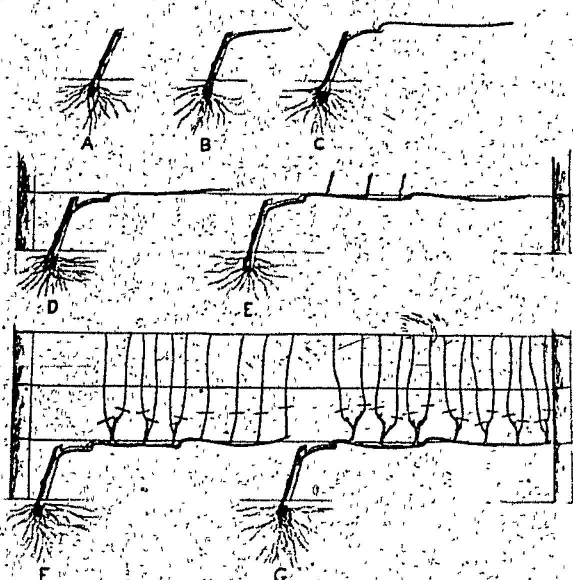

FIG. 48.—PRUNING IN THE GRAPE

intervals of a week during the early part of the growing season.

WINTER PROTECTION

In the northern sections of the Great Plains region plants of the grape require special protection during the winter. Both the stems and the roots are tender. A good covering of soil will provide ample protection for the varieties usually grown. Where the plants are pruned and trained as outlined above removal from the trellis may not be necessary. The pruned plants are merely covered by banking soil well over the horizontal trunks and the spurs that have been left on its upper side. The horizontal stem may be separated from its wire support and placed nearer the ground level for the

winter. A similar covering of soil is used and this can usually be given more easily than when the horizontal stem occupies its summer position. A bank of soil with a base three to four feet in diameter should cover the foot of the plant in all cases to provide protection for a portion of the root system. Where the Kniffen or some similar system has been used the vines must be taken from the trellis, placed on the ground and covered with soil. The covering should be removed in the spring before growth begins.

CHAPTER XIV

MISCELLANEOUS FRUITS

THE PIN CHERRY

REFERENCE has been made to the Pin Cherry (*Prunus pennsylvanica*) in the chapter on cherries. This is a native species that is found growing in sheltered locations and usually on the heavier types of soil. The plant grows to a height of twelve to fifteen feet under favourable conditions, and when growing in the open it may have a spread of several feet. Suckers are produced freely and these may arise some distance from the plant. The flowers are pure white, are borne in small more or less flat-topped clusters and usually appear in May. The fruit is dark red in colour, small, very acid and ripens about midsummer. It has a distinctive flavour and makes excellent jelly and delicious preserves. The fruit is a typical drupe.

Even though its fruit is small the pin cherry is worthy of cultivation. Under cultivation the plants do well and the fruit produced under those conditions is appreciably larger than that produced on untamed trees. As an ornamental shrub it has considerable value and makes a display that is not equalled by most other plants at that season.

Propagation.—The pin cherry can be propagated readily by seed. The seeds require after-ripening, and a period of four to five months at temperatures a few degrees above the freezing point and in a moist condition is sufficient to bring about the necessary pre-germination changes. The pits may be sown in moist soil out of doors immediately after the flesh has been removed, and before drying has occurred. Germination may not take place for two or three years where this treatment is given. The better treatment is that described for pits of the plum.

Superior forms of this cherry may be propagated by budding. Pin cherry seedlings should be used as stocks. Ordinary shield-budding should be satisfactory and the operation would be done at the normal time for plums and cherries.

Improvement.—The pin cherry doubtless offers possibilities for improvement to the fruit breeder. The plants are

extremely hardy and drouth-resistant and are able to do reasonably well under adverse conditions. While attempts to hybridize the pin cherry with the sweet and sour cherries have met with little success to date, a large fruited species or variety possessing quality and that will cross with this cherry will doubtless be found in the near future. When such a cherry has been discovered progress will be made rapidly and a new race of cherries will be founded. The beliefs possessed by certain fruit enthusiasts interested in the improvement of native fruits that progress can be made by selection alone will probably prove to be poorly founded in the case of the pin cherry, as the possibilities in that direction are too remote for marked results to be obtained during this generation at least.

The Chokecherry

The Chokecherry (*Prunus melanocarpa*) too is referred to in the discussion on cherries. This species is usually found growing in soils that are naturally moist but it occurs also on the higher land in sheltered locations. The flowers are white in colour and are produced in compact racemes. The fruit is a drupe which is usually black at maturity and consists to a large extent of pit. The small amount of flesh present, however, is juicy, sweet and very astringent.

Yellow-fruited forms of this cherry have been found in Nature. These are probably either mutations or bud-sports of the dark-fruited form. At least some of the light-fruited forms are very productive and their fruit appears to be unusually high in sugar and low in astringency.

This cherry has value both as an ornamental and as a source of fruit. Where it is to be grown it should be given a place as an ornamental and the fruit used merely incidentally. The plants should be given spacings of five to six feet and should be induced to grow in the bush form.

Propagation may be either by seeds or by suckers. The seeds require after-ripening and the pits should be given one of the treatments recommended for those of the plum. A period of five to six months is required, however. Suckers are frequently poorly rooted and only those that are well rooted should be transplanted.

It is doubtful that the yellow-fruited form will come true from seed. Seedlings of it being grown at the University of Saskatchewan have not reached the fruiting stage as yet, and the author has no information as to the heritability of this

yellow fruit character. At the present time the propagation of it by suckers is recommended.

THE HIGHBUSH CRANBERRY

The Highbush Cranberry or, properly speaking, the American Cranberry Bush (*Viburnum americanum*) is found growing chiefly on low-lying land that is naturally moist. It

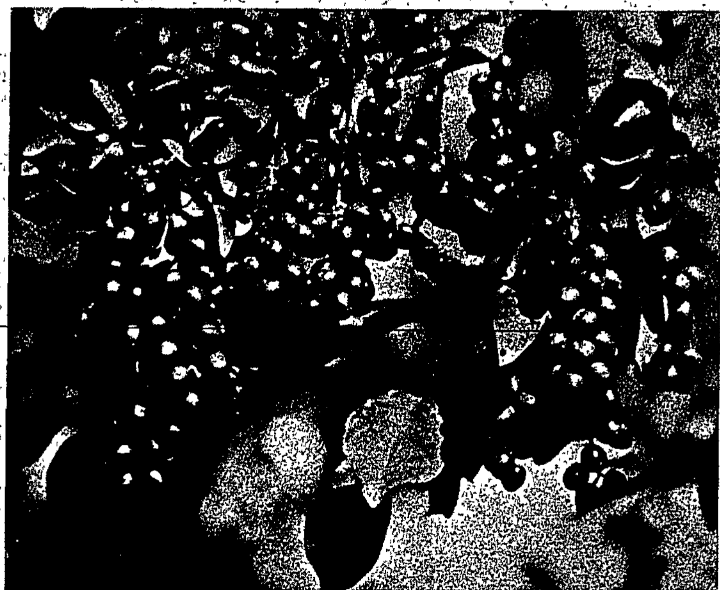

FIG. 49.—YELLOW-FRUITED CHOKECHERRY.

The fruits of this form are larger, sweeter and less astringent than those of the ordinary black-fruited form.

thrives on the heavier types of soil and favours those that are either neutral or slightly acid in reaction. Being shade-tolerant, and shade-loving to some degree, it is frequently found among trees that give it the protection from the direct rays of the sun that it enjoys. The flowers are white and are borne in large clusters that are broad and somewhat flattened. The fruit is red when ripe, juicy, very acid and very flavourful. It is drupe-like and the pit is very prominent.

This fruit should be cultivated much more than it is at present. The plant has value as an ornamental and may be grown as such on the heavier types of soil. The fruit is a valuable source of jelly and the jelly is of good colour and of

very high quality. By some the fruit of this species is used as preserves and is considered a delicacy. Propagation of this species can be effected readily by seed.

The seeds must be after-ripened and the treatment occupies a longer period than that for the seeds of many plants. When sown in the open without having been previously treated, the seeds may remain in the soil two or three years or more before germinating. This period can be shortened through the use of one of the standard methods for after-ripening seed. The best method is that of mixing the freshly extracted pits with moist sand and subjecting them to a temperature of 70°-80° F. for two to three months. At the end of that period exposure to a temperature of 40° F. approximately for two to three months should complete the necessary after-ripening.

The transplanting should be done early in the spring. The plants of this species are more difficult to transplant than are those of most species, and special effort must be made to move a good ball of soil with each plant. The plants should be set eight feet apart where they are being used for fruit production primarily but six-foot spacings are ample where they are being grown for ornamentation.

The Juneberry

The Juneberry or Serviceberry is one of the best-known native fruits. At least two species are found in western Canada. One of these is a tall form (*Amelanchier canadensis*) which grows to a height of fifteen to twenty feet and the other is a lower-growing form (*Amelanchier alnifolia*) which reaches a height of three feet only. The flowers are white in both species and are borne in short racemes. The fruit is a pome that is more or less juicy and that possesses an agreeable flavour. Considerable variation in size is found among the fruits but they are usually about the size of a pea. The colour is usually purplish-blue or black with a bloom present but both a red form and a white form have been found. The fruits of the red and white forms are usually much juicier than those of the darker forms.

The fruit of these species is very popular and has many uses. It is very palatable in the raw condition and is eaten out of the hand with relish. It makes a very acceptable dish when used on the table with sugar and cream. For preserves and pies it is excellent and for such is unsurpassed by other native fruits.

A variety of the juneberry has been introduced under the

name of Success. The fruit of this variety is reported to be much superior in size to that produced by ordinary plants. It is not grown to any extent, however, and few nurserymen have plants of it to offer.

The juneberry can be propagated readily by seed. The seeds should be allowed to dry and to remain dry for three months before being sown or before being given a special treatment. After-ripening is necessary and at the end of the period of dry storage the seeds should be mixed with a damp

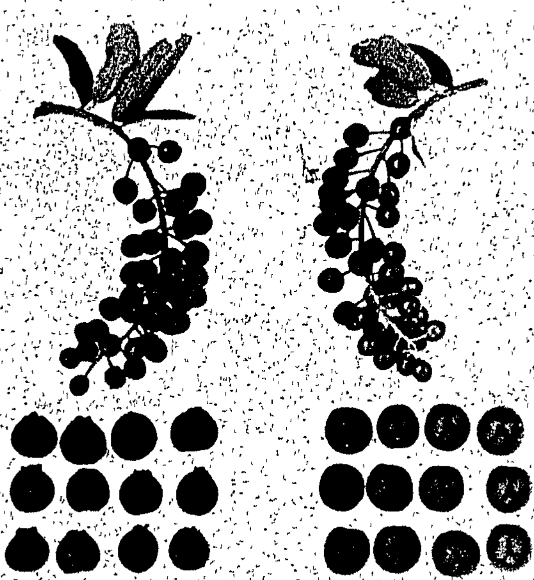

FIG. 50.—THREE NATIVE FRUITS

Chokecherry

Bessey Cherry Juneberry (Saskatoon)

The Juneberries are unusually large and were produced near Wembly, Alberta.

medium and after-ripened in the ordinary way. A period of three to four months at a temperature of 40° F. is necessary to complete the after-ripening process. Seedlings grow slowly and seldom fruit until six to eight years of age.

THE BUFFALOBERRY

The Silver Buffaloberry (*Shepherdia argentea*) is a native fruit that is not well known. The plants grow to a height of twelve to fifteen feet and may spread to cover considerable area. Unlike the American cranberry bush the silver buffalo-

berry is sun-loving and drouth-resistant and is frequently found growing on poor dry soils. The leaves are silvery in appearance and the bark a greyish-brown. The branches are well armed with thorns that are up to one and one-half to two inches in length. The plants are dioecious—the flowers being unisexual and the male flowers on one plant and the female flowers on another plant—and consequently only the plants bearing female flowers produce fruit. The fruit is a small drupe, either red or yellow in colour but nearly always red, and is borne in great clusters close to the branchlets and spurs. It is juicy, acid and with a flavour that is not altogether pleasing but is a source of excellent jelly and makes an acceptable pie. It could doubtless be used in other ways also.

While less desirable than many of the other native fruits the buffaloberry has a place in the garden. It should not be grown for its fruit primarily, however. It can be used to advantage either as an untrimmed hedge or in a border of shrubbery. Several plants should be grown to ensure the presence of representatives of both sexes and thus to ensure fruitfulness.

Propagation of this species is by seed. The seeds have a a long after-ripening period and the pits should be given one of the treatments outlined for the pits of the plum. Additional time should be allowed, however, as the seeds offer greater resistance to germination than do those of the plum.

Growth takes place slowly in this species and plants could not be expected to fruit before reaching the age of ten years at least. Spacings of six feet or more should be allowed excepting where the plants are being grown as a hedge when a distance of three feet between the plants is found ample.

The Blueberry

While several species of the blueberry occur in the prairie provinces only two of these are of importance. One is the Dwarf Blueberry (*Vaccinium caespitosum*, Michx.) and the other is the Canadian Blueberry (*Vaccinium canadense*, Richards). The plants of both species are low growing and are found on soils that are acid in reaction. The fruit of the former is blue with a distinct bloom and that of the latter is bluish-black with a bloom. The fruits of both species are juicy, flavourful and while inclined to be small are very palatable. Botanically the fruit is a berry.

Attempts to cultivate the blueberries on the prairies have been unsuccessful, in most cases at least. This has been due chiefly to lack of realization that the plants require an acid

soil and to the selection of an area that is not suited to the culture of this fruit. The blueberry is cultivated in certain places in America and good crops of fruit are obtained, but in such cases the acid soil conditions that the plants demand are provided. When such conditions are given to domesticated plants of this fruit in the prairie provinces successful culture and good crops of fruit in this section should result.

While the acidification of soils in parts of America for the culture of the blueberry and of certain other plants that require an acid soil is practised it is not practicable to do so here, in most cases at least. The soils in the prairie provinces that are alkaline in reaction have in most cases great reserves of lime and it would be a formidable task to acidify such a soil and to maintain in it an acid condition. Fairly high acidity is required for maximum growth in the blueberry, and soils that possess the necessary acidity and that are suitable for the culture of this plant are found in certain sections of the prairie region. It would appear advisable, therefore, to attempt to grow blueberries only in those parts where soils that are naturally acid are available and where the possibilities of the successful culture of this fruit are good.

The plants required may be transplanted from uncultivated areas or they may be grown from layers. Where whole plants are to be transferred only those that are sturdy and vigorous should be chosen and the younger plants are preferable to those older. The transplanting should be done early in the spring and the plants set about two feet apart in the row.

Mound-layering is the most satisfactory method of propagating this fruit. In the spring the bases of the stems are covered to a depth of a few inches with the soil in which the plants are growing. This necessitates the making of a bank of soil around the plant and among its branches. The soil in the mound must be kept moist during the summer and by fall the stems whose bases have been covered should be rooted. Early the following spring the bank of soil is removed and the rooted shoots excised and treated as separate plants. These may be set in the permanent location directly.

Seeds require after-ripening. Drying out should not occur, and a period of from three to four months is usually sufficient to complete the after-ripening process.

The Pear

The pear is closely related to the apple botanically, and belongs to the genus *Pyrus*. Like that of the apple, the fruit

P

of the pear is a pome but grit cells are present in the fruit of the latter and absent in fruit of the former.

Varieties of the pear cultivated in America have been derived chiefly from four species. These are: European Pear (*Pyrus communis*) from Europe and Western China; Japanese or Sand Pear (*Pyrus serotina*) from China and Japan; Siberian Pear (*Pyrus ussuriensis*) from Northern China, Manchuria and Siberia; and a Chinese pear (*Pyrus ovoidea*) from China. Plants of the first two species possess hardiness in moderate degree only and are susceptible to Fire-blight while those of the last two are very hardy and are resistant to this disease.

Most commercial pears owe their origin to *P. communis* and *P. serotina*. The most important variety grown in America at present, the Bartlett, is a variety of the former species and originated in Europe. The Seckel, an important commercial variety, is an American origination of this species. Of the other varieties grown in this group some are European introductions and some American. The Keiffer, a very popular variety in certain sections of America and one the plants of which possess considerable resistance to Fire-blight, is a hybrid between the two species.

Various forms of *P. ussuriensis* and *P. ovoidea* and hardy forms of *P. serotina* are being used in the development of pears for the Great Plains region. Progress has been made in this work and a few varieties possessing considerable hardiness have been developed. The varieties Mendel, Patten and Tait are representatives of this group. Some of these varieties are succeeding as far north as Morden, Manitoba, but it appears that, they lack the hardiness necessary for districts farther north. The fruits of these are of good size and of very fair quality at least.

Named varieties of the pear cannot be recommended for general culture in the prairie provinces of Canada at present. Those desirous of growing pears in most sections of this region should confine their plantings for the time being to forms of *P. ussuriensis*.

Propagation of named varieties of the pear is by budding. Seedlings of *P. ussuriensis* should be used as stocks for plants to be grown in northern regions.

Seed of pears should be handled in the same way as that of apples. The resistance to germination in the former is greater than that in the latter and a longer period of after-ripening is necessary. This is particularly true with imported seed and other seed that has been in a dry condition for a considerable time. An exposure of three to four months to ordinary after-

ripening conditions with temperatures between 34° F. and 41° F. is sufficient in the majority of cases to induce the seeds to germinate.

THE APRICOT

The apricot has not found a place as yet among fruits for

FIG. 51.—A PEAR TREE IN BLOOM

This is a tree of *Pyrus ussuriensis* in the fruit plantation of the University of Saskatchewan eleven years after planting and blooming the first time.

the Far North. A few plants of a hardy form have fruited in very favourable locations in Manitoba but the yields to date have been small and the quality of the fruit produced low. Crops of this fruit have not been reported either from Saskatchewan or Alberta and the author has knowledge only of a few plants that are being grown in these provinces. In North Dakota and South Dakota plants are reported to be producing fruit of fair quality.

The forms being grown are hardy botanical varieties of the Common Apricot (*Prunus armeniaca*). The form on which efforts have been concentrated in this region is *P. armeniaca* var. *mandschurica*. The fruit of this is yellow, juicy and palatable and reaches a diameter of one inch or slightly more. ~~A hardier form, *P. armeniaca* var. *sibirica*, is being grown to~~ some extent but the fruit of this is about one-half inch in diameter and is not edible.

Horticultural varieties of these hardy forms are not available as yet. Improvement work is being done and at some time in the future edible apricots sufficiently hardy to be grown successfully in the prairie provinces may be available.

Propagation of named varieties is by budding. Seedlings of one of the hardiest forms are used as stocks.

Seeds of the apricot germinate readily following after-ripening. Standard methods of after-ripening may be used and the process requires from two to three months under favourable conditions. Temperatures near 40° F. are the most favourable. Since the fruit is a typical drupe the pits should be treated in a manner similar to that for the plum and cherry.

THE MOUNTAIN ASH

While grown as an ornamental, the mountain ash is a fruit-producing plant of some importance. The chief use of the fruit is that of making jelly, and delightful jelly it makes, but there are doubtless other culinary uses to which the fruit could be put to advantage.

At least two species occur naturally in the prairie provinces of Canada. These are *Sorbus americana*, with long acuminate leaflets, and *Sorbus sambucifolia*, with obtuse leaflets. The fruit, which is a pome, is borne in large clusters and is scarlet in both species.

Propagation may be effected readily by means of seeds. The seeds are slow in germinating when sown outdoors in the ordinary way, but when properly after-ripened they will germinate readily. A period of three to four months at a temperature of 34° F., or 34° F. alternating daily or weekly with 41° F. and with the proper moisture conditions will bring about the necessary after-ripening changes.

The plant should always be grown in the bush form in northern districts. Being very subject to Sun-scald, plants are likely to succumb after a few years when grown in the tree form. Plants in the bush form, on the other hand, usually escape serious injury from this cause and live for many years.

THE WALNUT

The walnut cannot be regarded as a fruit of much importance in northern sections at the present time. It is being grown, however, and here and there trees that are doing moderately well are found. The Butternut (*Juglans cinerea*) appears to offer as much promise for the coldest parts of this region as any other form. Trees of this species that are making fair progress and that have been fruiting for several years in prairie sections of Saskatchewan are known. In all cases that have come to the attention of the author the trees are growing under very favourable conditions with regard to shelter and moisture supply, however.

It is very probable that hardy strains of this fruit will be found to do reasonably well in the park belts where shelter is abundant and where the precipitation exceeds that on the open prairie. Certain forms of the Manchurian Walnut (*Juglans mandschurica*), Japanese Walnut (*Juglans cordiformis*) and Black Walnut (*Juglans nigra*) may prove to be sufficiently hardy for northern sections and thus supply greater variety in this fruit. The last two are reported to be growing at Fargo, North Dakota, and strains that thrive there may be capable of giving rise to strains suited to conditions farther north.

Owing to the slowness of development in the plant it is doubtful that this fruit will occupy a place of importance in northern regions during the next fifty years. The so-called nut is a drupe and the seed is the meaty portion inside the bony "shell". Ordinary walnuts are propagated by seed. After-ripening is necessary and a period of several months with a temperature near 40° F. is required. Difficulty is frequently experienced in transplanting walnut trees successfully and the planting of the fruits where the trees are to remain is frequently recommended. In this case the fruits are planted about three inches below the ground surface. Planting of the untreated fruits in the fall may be practised, but the planting of after-ripened fruits early in the spring is preferable.

Named varieties of the walnuts are propagated by budding and grafting. Both methods are more difficult in this fruit than in most other fruits and the former is said to be the easier.

THE HAZELNUT

Two species of the hazelnut occur in the prairie provinces.

One is the Common Hazelnut (*Corylus americana*) and the other is the Beaked Hazelnut (*Corylus rostrata*). In the former the bracts surrounding the nut open and expose the mature fruit. In the latter the bracts are united and extend above the nut, forming a distinct beak. The nut in the former case is globular while in the latter it is ovoid.

The plants of both species are usually found in sheltered places along streams and in ravines. Lack of regularity in bearing is characteristic of both species and the crops are usually light.

Some effort has been made to cultivate these but little has been accomplished to date. In well-sheltered upland areas and in sections where the annual precipitation is reasonably good, plants of these fruits should find an environment to suit their needs and should produce fair crops of nuts.

This plant is commonly propagated by seed. The seeds offer considerable resistance to germination and after-ripening for a period of four to five months in moist storage at a temperature of 70° F. is necessary to overcome this resistance.

The Hawthorn

This is a native fruit found growing in thickets, ravines and protected places on hillsides. Two species (*Crataegus succulenta* and *Crataegus rotundifolia*) are commonly found. Plants of the former have stout thorns and produce round fruits while those of the latter have slender thorns and produce fruits that are slightly flattened. In both species the plants may reach a height of ten to twelve feet or more. Certain introduced species have proved to be fully hardy and these are being grown as ornamentals.

The fruits of the hawthorns, which are pomes, are edible and may be used in the making of jelly and preserves. The jelly is said to be excellent, but the addition of juice of an acid fruit to make the jelly set well is recommended.

Propagation of this plant is effected by means of seeds. The seeds of the hawthorn have bony seed-coats and are not unlike tiny nuts. These nut-like seeds do not germinate readily and require a moderately long period of after-ripening. When planted in the ground out of doors in the ordinary way they may not germinate until the third or fourth year or even later. The necessary after-ripening may be accomplished in one to two years in the presence of moisture and at a temperature near 40° F., however.

The hawthorn is not likely to be cultivated in the North primarily for its fruit. Because of its attractiveness and its extreme drouth-resistance the plant has considerable value as an ornamental and in time it will be widely used for massing and for the making of hedges. Plants thus employed should yield a fair amount of fruit that will be utilized one way or another in stocking the larder for the long winter approaching.

The Oak

This is probably the least important of our native edible fruits. Only one species, the Bur Oak (*Quercus macrocarpa*), has been reported from the Canadian prairies. It occurs naturally in a large section of Manitoba and in the southern parts of that province it makes a good tree. Its distribution in Saskatchewan appears to be confined to a belt in the eastern portion adjoining Manitoba. At the western limit of its range in Saskatchewan, this species grows as a small shrub. Alberta is not included in the range of this tree.

The oaks are propagated readily by seed. The seeds require after-ripening and this can usually be accomplished during a period of two to three months or less at a temperature of 40° F. Planted out of doors early in the fall the acorns, which are true nuts, should germinate the following spring. The nuts should not be allowed to dry excessively and should be placed in a moist medium for after-ripening indoors or planted in moist soil out of doors as soon as possible after being harvested.

CHAPTER XV

THE FRUIT PLANT AND THE FRUIT PLANT AT WORK

The General Nature of the Fruit Plant.—The plants usually classed as fruits are perennials. Unlike annuals that complete their life-cycles in one growing season and then die, perennials persist year after year, making growth and producing fruit each year. A state of dormancy is reached late in the autumn and this persists until the following spring. When the temperatures rise in the spring the plant again becomes active and, during the growing season following, it passes through its various stages of development.

Even though perennial, fruit plants differ greatly with respect to hardiness. The plants of some of the common fruits are very hardy and ordinarily survive the winters in very northerly regions where extremely low temperatures occur during certain months. The plants of others are less hardy and are quickly destroyed by low temperatures. In general the plants of tropical fruits are very tender; those of subtropical fruits less tender; and those of temperate fruits the hardiest. Considerable range in hardiness is found even in temperate fruits. The peach and apricot, for instance, are among the tenderest in this group, while the Canada plum, certain crab-apples and certain cherries are among the hardiest.

Fruit plants differ greatly in their general nature. In some fruits the plants are woody while in others the plants are more or less herbaceous. In the plant of the plum, for instance, the part above ground is woody and is not readily destroyed by low temperatures. In the plant of the strawberry, on the other hand, the parts above ground are not woody in nature and are destroyed by very low temperatures. In the raspberry the parts above ground are woody, but less so than in the plum, and are more easily destroyed by low temperatures than are the exposed parts of the latter. The parts above ground in some fruits reach considerable height while in others little vertical growth is made. The tree fruits are good examples of the former while the strawberry is a conspicuous example of the latter. Branching becomes very prominent in many tree fruits, while in the raspberries little branching

occurs. The plants of certain fruits bear thorns, spines and prickles while those of other fruits are without these sharp outgrowths. Each particular fruit plant has its own special characteristics and by these it is distinguished from others in the group.

The fruit plant is a highly organized individual with a number of distinct parts. The plum tree, for instance, has roots, a main stem or trunk, branches, leaves, flowers at a certain stage and fruits at a later stage. The roots and the base of the stem are below the ground-level while the other parts are above the ground surface. The root system is very complex and in most cases it permeates the soil in a large area. While usually reaching out in all directions a distance at least equivalent to the height of the plant, its roots frequently extend much farther than this. Where they join the base of the stem the roots are relatively large but they usually diminish in size rapidly, dividing and re-dividing until they become tiny fibres. On the fine roots are special absorbing organs known as root hairs. These are microscopic in size and are very delicate. In certain soils roots penetrate to a great depth but in most prairie soils the majority of the roots are found in the surface layer down to the depth of twelve to eighteen inches. The plant is held firmly in place by its roots. In the plum the main stem or trunk is usually short and from it arise the branches. The branches divide and re-divide and terminate in spurs and branchlets. Leaves are borne on the finer divisions of the branches and are found at definite places called nodes or joints. In some cases these nodes are several inches apart and one leaf is found at each joint while in other cases they are so close together that the leaves appear to be borne in clusters. In the axils of the leaves, from midsummer on, are found the buds that will give rise to flowers, leaves and new shoots the following year. The flowers are usually borne in small clusters and varying percentages of these give rise to the fruits that are harvested during the late summer and early autumn. The tree of the plum is, therefore, an individual consisting of many parts, all of which are necessary in the economy of the plant.

The general nature of the plants of other fruits is similar to that of plants of the plum. All have their roots, stems, leaves, flowers and fruits. Modifications occur, however, and certain parts may appear in one form in a given plant and in a different form in another plant. In the strawberry, the main stem is very short and is normally below the ground

level. It is referred to as the crown of the plant. From it arise the leaves and also the runners that result in an increase in the number of plants. In the grape the stems are very long and slender and require support. In the raspberry the stems are upright but are slender and possess sufficient flexibility to permit their being bent over and covered by soil or other material for the winter. Other fruits too have their special modifications which adapt them to the particular environment under which they grow.

The Cell is the Unit of Structure.—Under high magnification the fruit plant reveals a structure made up of a great many somewhat square or rectangular cells. These cells are very small and in some cases five hundred or more placed side by side are required to measure one inch. In general shape they are not unlike boxes and they fit together well in some cases and poorly in other cases. Where the cells lie close together the spaces between them are small but where they fit together poorly large spaces are found. These spaces are known as intercellular spaces. These intercellular spaces are found in great abundance in parts of the majority of plants and later it will be seen that these are advantageous to the plant. In most cases, each cell is firmly attached to the neighbouring cells and great numbers of these attached together in this way make up the plant. From the tips of its roots to the uppermost parts of the portion above ground the plant is a mass of such cells. Long, usually slender cylinders of them make up the roots; great numbers of them massed together make up the stems; and smaller groups constitute the leaves. Each group performs its special function, but all are so connected and their functions so co-ordinated that a harmonious unit results.

The normal plant cell has a well-defined wall. This wall is the cell boundary and offers support for the cell's contents. Unlike the walls of animal cells, the walls of mature plant cells are reasonably rigid and possess little elasticity and extensibility. The wall of the young cell is usually thin, while the wall of the old cell may be very thick. The cell wall is non-living but the active cell and many cells that are in dormant condition have living constituents.

The living constituents of the cell are known as protoplasm. Protoplasm is the physical basis of life and without protoplasm a plant or any other organism cannot live. This plant protoplasm or the living part of the plant cell may be divided into three parts which are known as the cytoplasm, nucleus and chromatophores. In a normal cell the cytoplasm

lines the cell wall and usually forms only a thin layer of living substance. The nucleus is a very essential part of the protoplasm and is usually either spherical or flattened in shape. It contains the bearers of heredity. The chromatophores are colour-bearers and these give plants their characteristic green colourings. In many cases other colours found in plants are due to the presence of these bodies. Certain other bodies also are frequently found in the protoplasm.

In addition to protoplasm the living cell contains water with various substances in solution. This is known as the cell sap and this fills the portion of the cell cavity not occupied by the protoplasm. The cell sap is necessary to the living cell and when the quantity of cell sap is reduced considerably, wilting of the plant or of certain parts of it takes place. When this reduction in cell sap is carried to the extreme, death of the cell usually results.

Cell Division and Cell Enlargement result in Growth.—Growth takes place by an increase in the number of cells and by an increase in the size of the cells already present. The cells increase in number by division. Under certain conditions, certain cells divide and two cells result from the division of one cell. In cell division, the essential parts of the nucleus divide and one-half of these parts is received by each cell resulting from the division of the original cell. This portion of the original nucleus received by the newly formed cell becomes the nucleus of the new cell. The new cell may be relatively small and it may increase in size considerably before its walls thicken. Many new cells being formed and many cells increasing in size are conditions found in growing plants and these either individually or together are responsible for the increase in size made.

After a time many of the cells of plants lose their living contents. Such cells may, however, be of great value to the plant. The heart-wood of trees is made up of masses of dead cells the walls of which have undergone change. The outer bark of trees is usually made up of dead cells. In both cases mentioned, the dead cells perform a service to the plant. In the former case they serve to strengthen the stem, while in the latter case they protect the living cells from injury.

Food Materials of the Fruit Plant.—The growing fruit plant must have food. If it is to grow rapidly the plant must have a generous supply of food of the proper kinds. When the food required is not present in adequate amounts, the plant will lack thriftiness and normal growth for the species

will not take place. The stature of the plant in such cases will be found to differ markedly from that of well-nourished plants of the same species. Under certain conditions the under-nourished plant will be dwarfed while in other cases it may be tall and slender. When the plant is well nourished, on the other hand, normal growth takes place and the characteristic form for the species is found. A continuous supply of food during the growing season, therefore, is necessary if the plant is to assert itself as Nature intended.

The plant supplied with green parts is able to manufacture its own food. It takes in food substances that are relatively simple in structure and from these it manufactures the foods required for tissue-building, for the production of energy and for storage. The plant may, therefore, be described as a food factory. Into it go the simple raw materials and in it these raw materials are converted into products of more complex structure that are used by the plant. In most cases only a portion of the products manufactured are used at once by the plant in its growth process, and the remainder is either stored in a special part or is distributed in a more or less general way throughout the plant for future use.

Essential Elements.—Certain elements are essential to plant growth. At one time the list of essential elements was definitely fixed but recent work on plant nutrition has demonstrated that the list is variable. In certain cases an element that was at one time considered actually harmful to plants has been found to be necessary for normal growth. On analysis the plant is usually found to contain a long list of chemical elements and a number of these are known not to be essential for growth, in certain cases at least. It is reasonable to suppose, however, that those non-essential elements present have been taken in by the plant and used in some way in its growth processes. Future work may reveal that these elements have important functions to perform in the economy of the plant. While the list is variable it has been agreed that carbon, oxygen, hydrogen, nitrogen, sulphur, potassium, phosphorus, calcium, magnesium and iron are the essential elements in most cases. When these elements are available to the plant in the proper forms and when favourable conditions are provided, normal growth will usually take place. Copper and boron are examples of elements that appear to be essential in the nutrition of certain plants. Sodium, chlorine and aluminum are good examples of elements frequently present that appear not to be essential to growth.

It is interesting to note that two of these elements usually

make up about 90 per cent of the total dry matter present in the plant. This dry matter is the material that is left after the moisture is driven off. The elements making up this large percentage are carbon and oxygen. These are frequently present in equal amounts approximately, although the amount of carbon usually exceeds slightly the amount of oxygen. Hydrogen is usually present to the extent of from 5 to 6 per cent of the total dry matter, while nitrogen varies from less than 1 per cent in wheat straw to over 4 per cent in the case of mature peas. The balance of the dry matter is made up of the other elements mentioned, but the percentage represented by these together is relatively low.

While it is customary to list the elements essential to growth it must not be understood that these are absorbed as such. All the elements mentioned are supplied to the plant in the form of compounds and this is probably the only form in which they may be utilized by the plant except in the case of oxygen. The plant uses oxygen that is combined with other elements, and also oxygen in the uncombined form. Further, a given element must be provided in a compound that can be utilized by the plant as a source for that particular element. In most cases, one or more of several compounds may be used as a source for an essential element. These compounds, that are utilized by the plant, therefore, comprise the food materials of the plant.

According to the form in which they are supplied to the plant these food materials may be classed as gases, water and nutrient salts. Those supplied as gases are carbon and oxygen. The carbon used by the plant is taken up only in the form of carbon dioxide. Some of the oxygen that is so necessary to the life processes of the plant is obtained from the gaseous form present in the atmosphere and it is taken up, as already indicated, in the uncombined form. Water is the important source of hydrogen and is an important source of oxygen also. Nitrogen, sulphur, potassium, phosphorus, calcium, magnesium and iron, the remaining essential elements, all must be supplied to the growing plant as salts, with few exceptions.

Sources of Food Materials for the Plant.—The sources of food materials for the plant that has become well established are the soil and the atmosphere. From the soil the growing plant obtains the water that furnishes hydrogen and oxygen. The amount of water required to furnish these elements is relatively small but it is essential to plant growth. The various nutrient salts that supply the nitrogen, sulphur,

potassium, phosphorus, calcium, magnesium and iron too are furnished by the soil. These are in solution in the soil water and must be in solution to be available to the plant. From the atmosphere the green plant takes up the carbon dioxide from which it obtains the carbon that makes up a large percentage of the dry matter present.

It is a noteworthy fact that approximately 50 per cent of the dry matter of the plant is taken from the atmosphere. Forty bushels of good wheat would probably represent about twenty-two hundred pounds of dry matter. The straw and the roots that produced this wheat might represent an additional two thousand pounds of dry matter. If the total dry matter of a forty-bushel wheat crop approximates forty-two hundred pounds, it follows that about two thousand pounds of this dry matter is obtained from carbon dioxide. For each acre producing forty bushels of wheat, nearly two thousand pounds of the dry matter of the plant therefore must be furnished each year by the atmosphere. From these figures the amount of carbon taken from the atmosphere each year by the wheat crop of Western Canada can be easily calculated. This, together with the amounts taken by other crops, reaches a staggering total of a few millions of tons at least.

If such large amounts of carbon are taken from the atmosphere each year, the stock of carbon dioxide from which the carbon is obtained must be replenished or the supply would eventually become exhausted. It has been found that the carbon dioxide content of the atmosphere remains remarkably uniform. The production of carbon dioxide must therefore equal the consumption of this compound. When a survey is made of the various processes going on in Nature during which carbon dioxide is released, it can readily be understood how the supply of this compound is maintained. In various life processes carbon dioxide is given off. Animals, including human beings, and plants all respire and give off carbon dioxide in large quantities. In the decaying of organic matter in the soil and elsewhere, carbon dioxide is liberated. In the burning of fuel, large amounts of this compound escape into the atmosphere. Everyone is aware that in the burning of wood the amount of ash left is small as compared with the amount of wood placed in the fire. Much of this loss in weight is brought about by the conversion of the carbon present in the wood into carbon dioxide that escapes as a gas. In many other processes, too, this compound is liberated and finds its way into the atmosphere. In every case, however, there is a loss in weight to the object suffering a loss in carbon.

By carefully controlled experiments, investigators have found that green plants absorb carbon dioxide from the atmosphere and use the carbon obtained from it in their life processes. If much of the loss in weight resulting in the burning of wood is due to the conversion of the carbon present into carbon dioxide that escapes as a gas, it is reasonable to suppose that increase in weight will result when carbon is taken from the carbon dioxide of the atmosphere by the growing plant and converted into plant-substance. This is in agreement with the facts as revealed by investigation, and since the carbon dioxide of the atmosphere is the sole source of carbon to the plant, it can be readily understood that a large part of the dry matter of the plant is contributed by the atmosphere.

The Assimilation of Carbon.—To be of value to the plant, the carbon supplied by the atmosphere must be split from the oxygen with which it is combined forming carbon dioxide. Under suitable environmental conditions, the green plant is able to split or to break down carbon dioxide and to build up compounds that are utilized by the plant in one way or another. The first stages of this process take place only in the green parts of plants or in parts containing the green colouring matter known as chlorophyll and take place only in the presence of light of a suitable intensity and of a suitable quality. The later stages of this process may take place either in light or in darkness. In the majority of green plants the general conditions necessary for growth must prevail if this process is to be carried on.

Photosynthesis.—The first stages in this process are known as photosynthesis. Photosynthesis is the building up of certain organic compounds that are used by the plant, through the action of suitable light in the presence of chlorophyll. Chlorophyll behaves as a sensitizer and makes use of the light waves of certain lengths in releasing the carbon from carbon dioxide and in utilizing it in the building up of compounds of direct value to the plant. Plants without chlorophyll or plants with chlorophyll in the absence of suitable light are unable to build up these compounds.

The breaking down of carbon dioxide takes place in the cell of the plant. Mention has been made of the fact that the higher plant is made up of many cells united together to form a unit. Many of these cells contain chlorophyll and these are able in the presence of the required light to effect the cleavage between the carbon and the oxygen of carbon dioxide that is so advantageous to the plant. Reference has been made to the intercellular spaces or the spaces between the cells found

in plants. These are usually abundant in the parts containing chlorophyll, and most of the cells have considerable portions of their walls exposed in these intercellular spaces. These intercellular spaces are in direct communication with the atmosphere through very small openings (stomata) in the outer covering of the organ and a free movement of air or of special gases in the air may take place in either direction. After entering the intercellular spaces the carbon dioxide passes through the wall of the cell in solution in the water contained in the cell wall, and is resolved into its elements in the cell. As the carbon dioxide in the intercellular spaces is used up in this process, more enters from the outside and while photosynthesis is going on a continuous movement of carbon dioxide is taking place from the atmosphere outside the plant to the intercellular spaces within the plant.

In the photosynthetic process either starch or sugar is formed. In some plants starch fails to appear, while in other cases it may be detected soon after the plant is exposed to light. The first product of photosynthesis is believed to be formaldehyde. The formaldehyde thus formed polymerizes or condenses, several molecules of it becoming one, and either starch or sugar results. Carbon, hydrogen and oxygen in certain combinations make formaldehyde. The carbon required is obtained, as already stated, from the carbon dioxide of the atmosphere. In the splitting of carbon dioxide, oxygen, as well as carbon, is released and some of this oxygen is used in the formation of formaldehyde. The hydrogen and probably the greater part of the oxygen required are obtained from the water that is taken up from the soil by the plant. Being made up of hydrogen and oxygen, water yields hydrogen and oxygen when broken down.

In order for photosynthesis to continue the products formed in the process must be removed. These are normally transported to some other part of the plant where they are used directly as a source of food or are stored for future use. In plants in which sugar is formed from formaldehyde further change of the products of photosynthesis before translocation takes place is unnecessary. Such sugar may be carried in solution to other parts of the plant, where it will be used as food or stored either as sugar or as some other product. Starch is not soluble in the water of the plant and cannot, therefore, be moved as such from one part of the plant to another part. In order to be moved to other parts of the plant it must be converted into a product that is soluble in the water of the plant. Starch formed from the condensation of

formaldehyde is converted into either sugar or protein or into both and translocation of the materials thus formed takes place.

Photosynthesis in Relation to Light.—In order for photosynthesis to take place light of a suitable quality and of a suitable intensity must be provided. Plants differ with respect to their light requirements and this may be seen in Nature where some plants grow naturally in shady places while others grow only in bright sunshine. Some house plants, for instance, require a place in a sunny window while other house plants will do well only away from the window in subdued light. Nearly all green plants, however, must have either daylight or strong artificial light part of the day at least if photosynthesis and growth, even approaching normal, are to take place. Very weak daylight, moonlight and light from an ordinary kerosene burner are of little value to the plant owing mainly to lack of intensity. Photosynthesis usually takes place chiefly at the red end of the visible spectrum and in most plants the maximum occurs in the red portion. Photosynthesis takes place of course, in the orange and yellow portions and some takes place in the green and blue portions but the amount in the latter cases is of little significance. While the red and the yellow portions are important and the green and blue portions unimportant as far as photosynthesis is concerned, the light of the blue end of the solar spectrum reaching the earth's surface, which includes some of the ultra-violet wave-lengths, is necessary to maintain normal growth in the plant.

Assimilation of Water.—Most of the water taken up by the plant is taken up from the soil by the root hairs found on the roots. These are very small organs and are outgrowths from the roots. The water enters these root hairs and from the root hairs it is passed on to the vessels through which conduction takes place. By these vessels water is carried to the various parts of the plant.

Only a small portion of the water taken up by the root hairs is assimilated. As will be shown later, the remainder is used for other purposes. That assimilated is broken down into hydrogen and oxygen and these elements combine with the carbon obtained from the atmosphere to form formaldehyde, and later to form starch, sugar and other compounds.

Assimilation of Nutrient Salts.—Certain nutrient salts are readily assimilated. Those referred to in this instance are chiefly the salts that are sources of nitrogen, phosphorus, potassium, sulphur, calcium, magnesium and iron to the plant. The essential parts of these salts are taken from the soil in solution in the water of the soil and enter the plant

through the root hairs. From the root hairs they are passed along to the vessels and in the vessels they are conducted to the parts of the plant at which they are required.

Little is known regarding how or where the essential parts of some of these salts are assimilated. It is known, however, that they are necessary for growth and that they occur in the plant. The rôles played by some of these is well known while the rôles played by others is not well understood.

Formation of Protein.—It has already been shown that sugar and starch are obtained from the carbon taken from the atmosphere and that the hydrogen and oxygen are obtained from the water taken from the soil. Further it has been stated that suitable light, in addition to the other conditions necessary for growth, is necessary for this process.

From some of the starch or sugar produced in photosynthesis, and certain of the elements supplied by the nutrient salts, protein is formed. The most important elements required by the plant for protein formation and that are supplied by the nutrient salts are probably nitrogen, phosphorus and sulphur. Magnesium usually accompanies proteins and it is possible that the other elements mentioned play an important part in the formation of these compounds.

Light is unnecessary for the formation of proteins. It is true that light is necessary for the first stages of the formation of starch and sugar which enter into proteins, but for the building of proteins from these substances and the elements supplied by nutrient salts light is not required. It is found, however, that the growing plant produces proteins both in light and in darkness and that the greater amount is usually produced in light. This is owing to the necessity of the presence of the products of photosynthesis and to the relatively large amounts of these products present during the hours of light. During the day, when starch and sugar are being formed, much protein is formed in the leaves where carbon assimilation is taking place. During the night protein may be formed in the leaves or in the other parts of the plant where the necessary materials are present. After the products of photosynthesis necessary for the production of proteins have been used up, further formation of protein will not take place until after a fresh supply either of starch or of sugar has been obtained. The opinion has been expressed that the formation of proteins may go on more rapidly in darkness than in light when an adequate supply of the products of photosynthesis is present but this view is not shared generally by authorities in this field.

CHAPTER XVI

THE FRUIT PLANT IN RELATION TO WATER

Importance of Water to the Plant

One of the most important compounds entering the plant is water. Water is indispensable to the living plant. When growing, most plants require this compound in moderate quantities at least and if this is not supplied in the amounts demanded by the plant normal growth will not take place. If the supply is reduced greatly, wilting will occur and death of the plant may result. Plants in the dormant condition too require water and, without this, survival is impossible. Both to the plant that is actively growing and to the plant that is resting, water is a prime necessity.

Amount of Water in the Plant.—Water usually makes up a large part of the growing plant. If a growing plant is removed from the soil in which it is anchored, is weighed at once, is then dried and is weighed again, considerable difference will be found between the two weights obtained. In other words, the fresh weight and the dry weight of the plant will be found to be very unlike. In the cases of very watery plants and fleshy fruits as high as 90 per cent or more of the fresh weight may be water and less than 10 per cent dry matter. In other cases, the water content may be lower and in the leaves and stems of some plants it drops to 40 per cent or less. Woody plants as a class contain less water than herbaceous plants.

The part of the plant concerned, the stage of growth and the season are important factors determining the amount of moisture present. Fleshy fruits are usually high in water while leaves and stems are relatively low. According to one authority the fruits of the apple contain 85·64 per cent water; the fruits of the pear 86·78 per cent; and the fruits of the gooseberry 89·42 per cent. In the fall the leaves of these fruits were found to contain 53 per cent, 38·20 per cent and 66·25 per cent respectively. For roots, branches and leaves of the walnut the values representing water content on July 31st obtained were 75·21 per cent, 68·30 per cent and 59·54 per cent respectively. New growth is usually higher in moisture than old growth. In the raspberry the water content of new growth was found to be 41·33 per cent and that for

old growth 33·52 per cent. In the gooseberry these values were found to be 44·20 per cent and 39·77 per cent respectively. As the season advances the water content of the branches decreases. The values representing moisture content of twigs of a plant of wealthy apple on May 13th, September 2nd and January 24th were found to be 65·5 per cent, 53·2 per cent and 45·7 per cent. For the Ben Davis apple these values were found to be 64·6 per cent, 55·2 per cent and 51·1 per cent.

Water in Seeds.—In mature seeds, water is usually present in small quantities only. Good wheat usually contains between 12 and 14 per cent moisture but may contain either less or more than this amount. At times wheat may be found containing moisture to the amount of 18 per cent or more. Most seeds in the fully mature stage and air-dried contain from 10 to 15 per cent moisture and the amount usually present in such seeds is necessary if viability is to be retained long. If moisture is present in abnormally large quantities, the seed may germinate or may be attacked by organisms of decay and destroyed. If the moisture content is made abnormally low by drying the seed at a high temperature, injury will be wrought and, if this drying is carried to the extreme, the destruction of the seed will result. Though present in relatively small quantities, the water in seeds is as necessary to the seed as is the water present in the roots, stems and leaves necessary to the growing plant.

WATER IN THE SOIL

Kinds of Water in the Soil.—The water in the soil may be divided into three classes. One class is known as "gravitational" water, and this is the water that moves through the soil under the influence of gravity. This water will normally drain away when the surface soil is underlaid by a porous subsoil. Another class is known as "capillary" water. This is the water that does not move downward in response to gravity and that is removed when the soil is air-dried under moist atmospheric conditions. The third class is known as "hygroscopic" and this is the water that is found in soils that have been air-dried in a moist atmosphere.

The amount of water that a soil will contain depends upon the amount of pore space present. In most soils the pore space has been found to range from 30 to 60 per cent of the total volume of soil and the water-holding capacity would therefore have this range. In sand and sandy soils the percentage

is toward the lower end of the range and in loam and loamy soils the percentage is toward the upper end of the range. These values represent the total of the three types of water present, namely: gravitational, capillary and hygroscopic. The hygroscopic moisture usually ranges from about 2½ to 10 per cent of the total volume of soil, though it may exceed the latter figure in certain soils. The capillary moisture in surface soils may range from about 3 to 45 per cent of the total volume of soil and the gravitational moisture constitutes the remainder. The lower values are for very sandy soils and the higher for clay soils.

Gravitational water is of no direct value to fruit plants. In fact it is harmful when in the portion of the soil occupied by the roots of the plant. It fills the cavities remaining after the hygroscopic and capillary capacities of the soil have been satisfied and prevents proper aeration which is so essential to normal growth. When a short distance below the region of the soil occupied by most of the roots, however, it may be of great value to the plant through its tendency to rise by capillarity, as the capillary moisture is reduced by absorption and evaporation. In such a case the gravitational water would become capillary water and would be helpful in maintaining a favourable moisture supply in the region occupied by the roots.

Capillary water is of great importance as far as the plant is concerned. This water exists as films around the tiny soil particles. In soils high in capillary water these films are relatively thick while in soils low in capillary water these films are relatively thin. These films are held in place by the force known as adhesion, but the absorptive powers of the root hairs of the plant are sufficiently great to overcome this to a great extent and the plant is able to take up the required water. As the films become thinner, as happens when the moisture content of the soil falls, it becomes more difficult for the plant to absorb water and finally a stage may be reached where the plant is no longer able to obtain sufficient to meet its needs. When this stage is reached, wilting occurs.

While usually considered as unavailable to the plant, hygroscopic moisture may be of some value to the fruit plant under certain conditions. Soils of the heavier types, with finely divided particles, are able to withdraw from a damp atmosphere considerable moisture, and this may be of material aid to certain plants during periods of drouth. Fruit plants are not able, however, to maintain normal growth on hygroscopic moisture, in any case, but at times and

under special conditions they may be able to survive when this is their sole source of moisture supply.

Movement of Water in the Soil.—Uniformity in moisture content is the tendency in soils of uniform nature. When the films of water become thinner in one place than in another there is a movement of water from the area where the films are thicker to the area where the films are thinner. When the soil is in a moderately dry condition a heavy rain may moisten well the surface layer to a depth of two or three inches. In this layer the films are relatively thick while in the layer below this the films may be very thin. A day or two later this surface layer which was very moist previously is found to be considerably less moist, owing chiefly to the movement of water in the direction of the drier layer below. As moisture is evaporated from the soil surface by wind and high temperatures, and the films on the soil particles near the surface become thin in consequence, a movement of water from the layers below to the surface takes place and a general drying of the soil results. In the same way moisture that has been removed from the soil immediately surrounding the roots is partially replaced at least by moisture in the soil near by. Thus water in the soil is in a state of movement until equilibrium has been attained.

Losses of Water from the Soil through Evaporation and Run-off.—Not all the moisture received by the surface layer of soil is available to the plant. Much of this is lost through run-off and evaporation from the soil direct. When the ground is frozen the run-off may be great and even in the summer during a heavy rain this is frequently considerable in the case of the heavier types of soil. Run-off has been found to be less in a grassed area than in one under cultivation. The losses from the soil direct through evaporation are usually high. Much depends, of course, upon conditions. Where a soil covering, such as a mulch of straw, is used the losses from evaporation are very small, while in an unprotected summer-fallowed field that has been neglected and in which the soil has been allowed to develop cracks the losses may be very high. It has been estimated by good authorities that from 50 to 65 per cent of the moisture from precipitation is lost through run-off and evaporation even where good cultural methods are employed. There are doubtless instances where the losses are even greater than these. In the case of the fruit plantation where the area is favourably located and where the soil has considerable protection from the plants, these losses should approach the minimum for bare land.

Since the supply of moisture in prairie regions is very limited and since plants growing in most parts of these regions are wholly dependent upon the moisture from precipitation, the reduction of these losses to the minimum in the fruit plantation is very necessary. Rate of air movement is an important factor influencing the rate of evaporation from the soil and by using proper shelter the grower can reduce greatly the velocity of the air in the fruit plantation during windy weather and thus conserve soil moisture. Tillage as often as is necessary to maintain a soil mulch and to destroy weeds will do much in reducing unnecessary losses of water from the soil through evaporation. Leaving the surface of the soil rough in the fall may assist in checking run-off in the spring. Keeping this surface rough during the summer may do much in checking run-off from heavy rains, but the increase in the surface area exposed would increase the total evaporation and this increase might more than equal any saving effected in the run-off. The use of either grass or some other crop in the fruit plantation will reduce both run-off and evaporation from the soil direct but the consumption of moisture by the crop used would in some cases at least exceed that conserved through the saving in run-off and evaporation. A mulch of straw or of other litter is very effective in conserving moisture in the soil and in increasing the efficiency of the precipitation in producing a crop and its use is practicable in many cases.

The Absorption of Water

Most of the water taken up by the plant is absorbed from the soil by the root hairs. The root hairs are very tiny organs found on the roots of growing plants and are mere outgrowths from the roots. These hairs come in direct contact with the films of water surrounding the soil particles. The water from the soil passes through the walls of the root hairs into cavities and from the cavities of the root hairs it is passed to the vessels in the roots through which conduction takes place. These vessels are connected with similar vessels in the stem and branches. Through these vessels water is carried to the various parts of the plants.

Some water is absorbed from the soil by the roots without the medium of root hairs. The amount absorbed in this way is small, however, and is not sufficient to meet the needs of the actively growing plant. Though very limited in amount such water frequently carries the plant over critical periods

following the destruction of the normal organs of absorption.

Even the dead roots of a plant may take up water from the soil. The rate of absorption in this case is very low but the water thus absorbed may be sufficient at times to prevent injury from drying in the exposed parts of the plant.

Factors determining Rate of Absorption of Water.—The rate at which water is absorbed by the plant is determined by a number of factors. The most important of these are: (1) the rate at which the plant uses water, (2) the physical nature of the soil, (3) the amount of water in the soil, (4) the amount of mineral salts in solution, ~~(5) the nature of the salts in~~ solution, (6) the chemical reaction of the soil, (7) the amount of soil aeration and (8) the soil temperature.

Consumption and absorption of water by the plant are closely related. When the rate of consumption of water is high the rate of absorption must be high if the plant is to remain rigid. When conditions for absorption are favourable the intake will virtually equal the consumption even when the latter is high. When the rate of consumption is low, as on a dull or cloudy day or during the night, ~~the rate of~~ absorption will be low though it might exceed slightly the consumption. In such cases some water may be forced through tiny openings at the margin of the leaf as a result of high pressure developed within the plant.

The physical nature of the soil influences the rate of absorption through its relation to the ability of the soil to deliver water to the plant. Water in a sandy soil is not held firmly and such a soil will give up its water to the plant freely. In a heavy soil water is held more firmly and soils of this type will deliver water to the plant more slowly. Under certain conditions the rate of absorption from a light soil may be greater than the rate of absorption from a heavier soil.

The amount of water in the soil has an important relation to the rate of absorption. A dry soil holds its water firmly while a moist soil of the same texture holds its water less firmly. Plants growing in a dry soil may have difficulty in obtaining sufficient moisture to supply their needs and at times may suffer from lack of moisture. Plants growing in a moist soil, on the other hand, may never want for moisture. For the best development in the majority of plants the soil should be from 40 to 50 per cent saturated. This provides air space to the extent of 50 to 60 per cent.

Not infrequently is the amount of mineral salts in solution

a factor in determining the rate of absorption by the plant and consequently the growth rate. If the mineral salts in solution are in excess, the plant is unable to take up the required amount of water from the soil and is unable to make normal growth. If the soil contains much so-called "alkali", most plants are unable to thrive owing to the high concentration of the salts in solution. When artificial fertilizers are used in excess and are placed near the roots of the plant the concentration of the soil solution becomes excessive and absorption is difficult. Plants differ with respect to their tolerance of salts in the soil, however, and certain plants will thrive even in the presence of large quantities of certain salts in solution.

Certain salts found in the soil are without value to the plant, and, when present in considerable amounts, retard growth. Examples of such salts are sodium sulphate, magnesium sulphate and sodium carbonate. These salts mainly are responsible for the "alkali" that is frequently found in prairie soils. Most plants are not highly tolerant of these salts and, when growing in a soil containing even moderate quantities, they make poor growth and consequently absorb water slowly. When present even in small quantities certain salts are toxic to plants and plants growing in soils containing these fail to thrive and have a low water absorption rate.

The chemical reaction of the soil is an important factor conditioning the rate of absorption of water by the plant. Until recently it was thought that acids stimulated the absorption of water but it has been shown beyond doubt that acids invariably decrease the rate of absorption. In some cases the decreases amounted to 40 per cent. While a change in the reaction of the soil solution results in a change in the solubility of certain salts in the soil, the rate of absorption of water by the plant may be considered to be greater in a soil that is slightly alkaline than in one that has an acid reaction.

Fruit plants growing on a well-aerated soil absorb more water and make better growth than do similar plants growing on a poorly aerated soil. Oxygen is required by the roots of the plant and by certain micro-organisms in the soil that are beneficial to plants. Certain gases, notably carbon dioxide, given off by the roots and by bacteria and other minute organisms are injurious to the plant both directly and indirectly and, if these are allowed to accumulate, a depression in water absorption and in the growth rate will result. If the soil is well drained and is not unduly firmed, aeration will take place readily and the gas content of that portion occupied by

the majority of the roots should be such as to give the most favourable water absorption.

Soil temperature exerts a marked influence on water absorption. As the temperature of the soil drops the rate of water absorption decreases. A cold soil, even though moist, is a dry soil to the plant. During the season when water is in greatest demand by the plant the temperature of the soil is usually sufficiently high to permit absorption at the required rate. Under certain conditions, however, the temperature of the soil may be so low as not to permit the absorption of water at a sufficient rate to supply the needs of the plant and wilting in such cases occurs. For instance, the use of a winter mulch among trees and shrubs usually delays the escape of frost from the soil in the spring and the plants concerned may leaf out and begin transpiring rapidly before absorption of water at the rate demanded by the plant is possible. In such a case the new leaves may be destroyed and the plant given a severe set-back. During the winter the moisture demands of the plant are small and even though the temperature of the soil is below the freezing point absorption of the necessary water usually takes place without difficulty.

It is interesting to note that considerable water remains in the frozen layer of soil in an unfrozen condition during the winter. If this were not true, woody plants in certain regions would dry out and die. Since frost penetrates to a depth of eight feet in places where fruits are grown all the roots of many of these plants are found in the area subject to freezing. It has been pointed out that plants of this class give off moisture during the winter and that absorption of water at that season is necessary if the life of the plant is to be maintained. It is true that some of the moisture in this layer is frozen at temperatures slightly below the freezing point but even at temperatures of $-100°$ F. some water in the soil remains in an unfrozen condition. It is seldom that the soil temperature drops below $-15°$ F. at a depth of six inches and below $0°$ F. at a depth of one foot, and at these temperatures much of the soil water remains in an unfrozen condition throughout the winter months.

Wilting in Plants.—The wilting that frequently occurs in plants may be temporary or permanent. On a very hot day during the summer, for instance, plants may wilt and resume rigidity towards evening or during the night. This is referred to as temporary wilting and the results are seldom serious as far as the plant is concerned. In other cases wilting occurs and the plant is unable to resume rigidity even under the most

favourable atmospheric conditions. This is known as permanent wilting and the plant is either seriously injured or destroyed. At the time wilting occurs the amount of capillary water present may be considerable or small, depending upon the evaporating power of the atmosphere. If the evaporating power of the atmosphere is great, wilting may occur with a fairly large amount of moisture present but if the evaporating power of the air is not great, wilting seldom occurs until the amount of water present in the soil has reached a low point. In the former case the wilting is usually temporary while in the latter case it may be either temporary or permanent. It is generally agreed that permanent wilting occurs in most plants at least, even when the evaporating power of the air is low, before all the capillary water is removed. The point of permanent wilting for a soil has been given by certain authorities on the subject as that where the moisture content has dropped to approximately one and one-half times the hygroscopic moisture content of the soil. For instance, in a soil with a hygroscopic moisture content of 5 per cent the wilting point for plants would be reached when the moisture content of the soil dropped to 7½ per cent or slightly below this.

Rôle of Water Absorbed.—The water absorbed by the plant is used in various ways. Mention has already been made of the fact that part of the water taken up by the plant is assimilated and is the source of hydrogen and a very important source of oxygen to the plant. In addition to this, water provides the medium for the transportation of mobile materials within the plant. It plays a very important part in maintaining rigidity in the plant and a large amount of it is given off in transpiration, which appears to be a necessary process in the life of the plant.

TRANSPIRATION

Transpiration is the giving off of water in the form of water vapour by living plants. During the growing season most of the water thus transpired is given off through minute pores in the leaves termed stomata. A small amount, however, is given off through the cuticle and more is given off in this way from young leaves than from older leaves. These pores lead to the intercellular spaces referred to above and these intercellular spaces are bordered by living cells containing water. The cells bordering on these spaces permit water to pass through their walls into the intercellular spaces and from the intercellular

spaces the water escapes to the atmosphere in the form of water vapour. This evaporation of water results in a minus pressure of water in the cells bordering on the intercellular spaces and creates what is known in everyday language as suction. Water is then drawn from neighbouring cells not bordering on intercellular spaces and in which the water pressure is greater. These cells in turn draw water from other cells having a greater water pressure and this process mainly is believed to be responsible for the rise of sap in plants. This process continues until conditions no longer permit transpiration to take place. Some water is given off through small openings that are present in the stem and branches, but this is usually a small part of the total amount given off by the plant during the growing season. During the dormant season woody plants give off small amounts of water and throughout the winter months this loss of water continues to take place. Deciduous trees and shrubs give off the water lost during this season through the bark of the stems, branches and twigs while evergreens give off water not only through the bark of the stems, branches and twigs but through the leaves also. The amount given off during the winter is very small, however, as compared with that given off during the growing season.

The Purpose of Transpiration.—The purpose of transpiration is not well understood. Theories advanced as to the purpose of transpiration are somewhat conflicting and authorities on the subject of plant physiology disagree to some extent on this point. It has been assumed that its chief purpose is to keep down the temperature of the plant. Inanimate objects frequently become very warm when exposed to the direct rays of the sun and, in many cases, such objects reach temperatures many degrees higher than the temperature of the atmosphere. It has been observed that the temperature of a plant exposed to the sun seldom reaches a temperature more than a few degrees above that of the surrounding atmosphere and that in many cases its temperature is lower. It is known that the conversion of water into water vapour requires much heat and it has been assumed that this vaporization of water by the leaves of the plant consumes much of the heat energy absorbed by these parts. The plant using up heat energy in this way tends to keep cool. This is a reasonable supposition and, until more is known about the process, it might be assumed that at least one of the important purposes of transpiration is to keep the plant from becoming overheated.

By some students of biology it is maintained that trans-

piration is Nature's way of disposing of the unused portion of the water absorbed by the plant in taking up the necessary salts from the soil. Such students hold the view that the amount of salts taken up is proportional to the amount of water absorbed, and that a plant requiring large amounts of these salts must of necessity take up a large quantity of water. This view is no longer accepted by botanists and is not in accord with the revelations of modern plant physiology. It is true that the salts in question are absorbed in solution but they and the water are absorbed independently. No relation between the amount of salts and the amount of water taken up by the plant exists therefore. On one day or at one hour in the day there may be a heavy call on one salt and a light call on another salt and these are taken up in the quantities required irrespective of the amount of water absorbed. Salts are required by the plant during the night when the transpiration rate frequently approximates zero, and if a relation between the amount of salts taken in and the amount of water absorbed prevailed the plant would be unable to obtain the necessary supply of salts between the time transpiration reached a low ebb one day and the hour at which it began to increase rapidly on the following day. Thus the view held by this group of students may be cast aside and the former view accepted, for the time being at least.

The Rate of Transpiration.—Large quantities of water are given off by the plant in transpiration. It has been shown that a sunflower plant six feet in height may give off on a hot day three pounds of water or more. A large corn plant has been found to evaporate nearly ten pounds of water in one day under certain conditions. It has been estimated that over one hundred gallons of water may be given off by a large birch tree in one day during warm, dry weather. One acre of birch trees would probably give off during the warm summer months an average of five hundred barrels of water a day. One acre of wheat probably transpires each day during July one hundred barrels of water or more. Definite figures for fruit plants are not available but the amounts for a given area devoted to fruits would probably approximate that for wheat. It has been estimated, however, that a large apple tree will lose twenty-five gallons a day and thirty-six hundred gallons during a growing season. Some plants give off larger amounts than those mentioned while others give off smaller amounts.

Factors determining Rate of Transpiration.—The rate of transpiration in a given plant is determined by a number of

factors. The most important of these are: (1) the health and vigour of the plant, (2) the stage of growth, (3) the water content of the tissues giving off water and (4) atmospheric conditions.

The stage of growth and the health and vigour of the plant influence the rate of transpiration in a marked degree. As a rule healthy and vigorous plants transpire at a more rapid rate for a given leaf area than do plants lacking in vigour. In general, plants in the earlier stages of growth lose more water for a given leaf area than do the same plants in the later stages of growth. The total amount given off by a plant for a given period may reach its maximum, however, toward the end of the period of marked vegetative growth for the particular plant concerned.

The amount of water in the evaporating tissues plays an important part in determining the rate of transpiration. If the rate of transpiration is to be at its maximum at a given time, the cells in these tissues must be filled with water. As transpiration progresses the water in the cells diminishes unless the losses are made up through absorption. The supply of water in these cells, therefore, is conditioned by the absorption rate. If the maximum absorption rate is slightly greater than the maximum transpiration rate at a given time, these cells will remain filled. If the maximum absorption rate is lower than the maximum transpiration rate at a given time, on the other hand, these cells will not be fully charged with water and the transpiration rate will decrease as a result.

The condition of the atmosphere is a major factor influencing the loss of water through the exposed plant parts. The atmospheric conditions that lead to high transpiration rates are bright sunlight, a dry atmosphere, a rapid air movement and a high temperature. Any one of these conditions may be responsible for a very large part of an increase experienced in a given case and in Nature all four frequently operate at a given time. All may operate on a summer's day, and at that time the rate of transpiration may be very high. During the night at such a time when the temperature is relatively low, when darkness prevails, when the atmosphere is nearly saturated with moisture and when the air is still, the rate may be reduced virtually to zero. It may be noted, however, that temperature has no direct effect on the rate of transpiration and that an increase in temperature increases the rate of transpiration through increasing the saturation deficit of the air or the moisture-holding capacity of the air.

Light as a factor determining the rate of transpiration is worthy of special mention. Through favouring the opening of the pores leading to the intercellular spaces and through increasing the permeability of the protoplasm of the evaporating cells, light increases the transpiration rate. Over 80 per cent of the radiant energy absorbed by plants is used up in transpiration and conditions permitting the absorption of much of this energy tend to accelerate transpiration. On a bright sunny day the transpiration rate may be several times that on a dull day. Most of the transpiration taking place occurs during the day and the difference between the day and night rates is due in a large measure to the difference in the supplies of radiant energy at these times.

It is interesting to note that a coating of Bordeaux Mixture may increase the transpiration rate greatly under certain conditions. Bordeaux Mixture is a standard fungicide and it is frequently used as a spray in the control of certain fungous diseases. The greatest increases have been found to occur during the night when the values for sprayed plants reached a point nearly 500 per cent above those for unsprayed plants. On cloudy days increases as high as 21 per cent were obtained as a result of spraying with this mixture. For the twenty-four-hour period the increases were as high as 23 per cent during fair weather and 63 per cent during cloudy weather. It has been found that this spray accelerates transpiration through the cuticle only, and that it tends to depress slightly the rate of transpiration through the pores or stomates.

Water Requirements of Plants

The number of units of water used by the plant for each unit of dry matter produced is known as the "water requirement" of the plant. The water requirements of plants in general are high though a great variation is found. The values for many plants have been worked out. For each pound of dry matter produced the amount of water required by the majority of cultivated plants has been found to be between two hundred and one thousand pounds. Some plants are economical in the use of water while others are extravagant. The corn plant has been found to be fairly economical in this respect and under average conditions it requires only slightly over two hundred pounds of water for each pound of dry matter produced. Wheat, oats and barley are not as economical as corn and their values usually lie between three hundred

and four hundred. Alfalfa, western rye grass, brome grass and other fodder plants are very extravagant in the use of water and their values usually exceed eight hundred. Oak trees are stated to require from two hundred to three hundred pounds of water for each pound of dry matter produced, while the values for pines, spruces and firs lie between thirty and sixty. Definite values for fruit plants are not available, but they may be assumed to be moderately economical in the use of water. The tree fruits are probably more economical than the bush fruits and the strawberry and the raspberry are probably among the most extravagant.

Factors affecting Water Requirements of Plants.—Environmental conditions play an important part in determining the water requirements of a green plant. Under certain conditions the water requirement of a given plant will be high while under other conditions it may be found to be very much lower. The differences in such cases are due mainly to differences in the environmental conditions. Elements of the environment playing an important part in this respect are: (1) the nature and the amount of plant food in solution in the soil, (2) the amount of moisture in the soil, (3) light and (4) general conditions.

The concentration of the soil solution is worthy of special mention in this connection. In rich soils, where plant food of the right kind and in the proper form is present in large amounts, the water requirement is relatively low while in soils low in fertility the water requirement is relatively high. In carefully controlled experiments the value in the former case for a certain crop under a given set of conditions was found to be two hundred and thirty-six pounds and, in the latter case, where the soil was poor, this value reached six hundred and five pounds. In this case the water requirement in poor soil was nearly three times that in a fertile soil. It is because of this in part that good yields are possible under prairie conditions where the annual precipitation is low. As the fertility of the soil decreases, yields will undoubtedly decrease accordingly and the present system of farming will eventually give way to a system in which more fertility will be added to the soil. Any treatment, therefore, that will add fertility to the soil and thus increase the concentration of the soil solution will tend to reduce the water requirements of the plants being grown and will increase yields.

The amount of moisture in the soil may exert an influence on the water requirement of the plant in two different ways at least. It has been found that the water requirement

decreases as the amount of soil moisture decreases. With a decrease in soil moisture, an increase in the concentration of the soil solution occurs and the effect in this case is through the change in the concentration of the soil solution. Owing to the insufficient aeration soils high in moisture provide less favourable conditions for growth than do soils containing a moderate amount of moisture even where the concentration of the soil solution is high. With a decrease in the soil moisture the various chemical changes taking place in the soil upon which growth depends in part are accelerated and conditions for growth are made more favourable. It has been found that the more favourable soil conditions are for growth the lower is the water requirement.

While markedly affecting the transpiration rate, light has an important effect on the water requirement of the plant. Most plants transpire slowly in the shade and rapidly in sunlight provided other conditions are favourable for transpiration. The manufacture of food takes place slowly in shade and rapidly in sunlight. The increase in food manufacture is more rapid than the increase in water consumption in many plants and less water is required to produce a unit of dry matter in sunlight than is required in shade in such cases. Figures for a few broad-leaved plants show that the water requirements for shade are from 20 to 40 per cent greater than those for sunlight. In certain other plants, however, the reverse is true and the water requirement for shade is considerably lower than that for sunlight. For the Scotch pine, for instance, the value for shade is slightly more than one-fourth the value for sunlight.

Investigations have shown that the environment in general has an important effect on the water requirements of plants. Plants growing in a favourable environment usually have the minimum water requirement and plants of the same species growing in conditions that are unfavourable usually have a much higher water requirement. The difference may be very marked and under certain conditions the water requirement in one case may reach a value three times the water requirement in the other case or more. Differences in the environment have doubtless been responsible, in part at least, for the differences in the values representing the water requirements for certain plants obtained by different investigators.

In view of the facts mentioned the grower of fruits would do well to provide for his plants an environment that is as favourable for normal development as possible. The plants

should not be crowded and should be well away from plants of other species. Prunings should be given to admit abundance of sunlight when they are needed. A suitable soil that has been well fertilized should be employed. Cultivation should be given to destroy weeds and to aerate the soil and any other practical treatment that will make the environment more favourable to the plant should not be withheld.

Importance of Rigidity.—In order to grow the plant must remain rigid. In the wilted condition a plant is unable to carry on its normal life processes. Wilting occurs when the outgo of water exceeds the income and when the water content of the plant falls considerably. If the parts of the plant that lack strong-supporting tissues are to remain rigid and if growth is to take place, the cells must be filled with water. Water performs a very important function in maintaining rigidity in the plant and in providing favourable conditions for growth.

Water as a Carrier.—The movement of materials is an essential part of the life processes of the plant. In order to move and to become available for use in other parts these substances must have a medium in which to move and water is the medium provided by Nature. The salts taken from the soil by the plant are absorbed in solution and carried, from the root to the part of the plant in which they are to be used, in solution in the water of the plant. Much of the organic matter manufactured by the plant must be moved from one part of the plant to another part and this is possible only through the medium of water. Thus, water as a carrier is indispensable in the life of the plant.

Abnormal Conditions in the Plant associated with an Excess and with a Shortage of Water

For the best results fruit plants should have during the growing season a moderate and steady supply of moisture. This results in normal growth and in a normal condition of the plant. When moisture is present in excess or when a shortage of it exists, on the other hand, abnormal conditions in the plant are usually found. Such conditions frequently found are: early defoliation, die-back, fruit splitting and second growth.

Early Defoliation of the plants frequently occurs as a result of prolonged drouth. The fruit fails to develop to its normal size and lacks quality when mature. The wood ripens early and the leaves turn yellow and drop before the normal time

for defoliation. This robs the plant of some of the food that it normally manufactures late in the season and stores in the woody tissues for use early the following spring. It also robs the plant of some of the essential elements, particularly nitrogen and phosphorus, that are transferred, in the ordinary course of events, from the leaves to the stem. When the leaves drop prematurely this transfer takes place in part only and the plant suffers a shortage of these elements as a result. In addition, early defoliation is likely to affect the behaviour of the plant the following year through preventing the normal development of both the leaf buds and the flower buds.

Die-back is a condition more serious than the drouth injury that results in early defoliation. In this case the twigs and branches die back through shortage of moisture. This may occur late in the fall after defoliation but it usually occurs during the winter. More is likely to occur where the plants are exposed to winds than where the plants are well protected. This condition is usually attributed to lack of inherent hardiness in the plant or to improper maturity of the wood but much of that occurring is the result of the presence of an insufficient supply of moisture in the soil during the winter. Moisture is given off through the bark of the stem and branches throughout the winter and unless water is absorbed at that season to make up that given off, drying of the branches will result. When this drying reaches a certain point, death of the part or parts concerned occurs and the condition known as die-back results. Being most exposed and farthest from the source of moisture the tips of the branches are killed first and the drying and killing progress down the stems until the surface of the living branches has been reduced to the point where evaporation does not exceed absorption.

While little can be done to reduce or to prevent die-back in the majority of fruit plantations, the trouble may be prevented in certain cases. Since die-back is caused by shortage of water chiefly during the winter months, irrigation in the late fall, or just before winter sets in, is a good measure of prevention. Where water can be given, the soil for some distance around the plant should be well moistened. Good cultural practices during the summer that conserve the moisture will assist in preventing both drouth injury and die-back.

Fruit-splitting is associated with the presence of considerable moisture in the soil after a prolonged dry spell. The skin breaks and the flesh splits. This condition is frequently found in plums and cherries. Development in the fruit is retarded

during the dry period by the much reduced supply of moisture and the skin and the outer layers of flesh lose their ability to expand rapidly. Following such a dry period a heavy rain accelerates development in the fruit and, being unable to keep pace with the rapidly expanding inner fleshy part, the skin and the outer ring of flesh break and the splitting results.

Maintaining a fairly uniform supply of moisture in the soil will usually prevent fruit splitting. While this is not practicable in most cases, the use of measures to conserve soil moisture will assist greatly in the prevention of this injury.

Second Growth in the shoots and branches of certain fruits frequently occurs when heavy late summer rains follow a long dry period. Normally most of the vegetative growth taking place in these plants occurs early in the season and, by the end of the summer, especially when the summer has been dry, this wood is well matured. If the weather is mild, the abundance of moisture supplied by these late rains will frequently initiate growth and many of the buds, that would normally remain dormant until the following spring, open and produce shoots. These shoots seldom mature properly before winter sets in and may be partially or wholly destroyed before spring.

Little can be done to prevent this beyond following good cultural practices and maintaining a fair supply of moisture in the soil throughout the growing season. With such a supply of moisture the plants will not ripen their wood abnormally early and the buds are not likely to be opened by warm autumn rains.

CHAPTER XVII

THE FRUIT PLANT IN RELATION TO TEMPERATURE

Grouping of Fruits according to Hardiness.—Fruit plants of the northern hemisphere may be grouped conveniently according to their temperature requirements. Several groups may be made on this basis and the list might comprise: tropical, sub-tropical, south temperate, north temperate and boreal. Tropical fruits are found in the banana, pine-apple, date and olive. Among sub-tropical fruits are the orange, lemon, grape-fruit, fig and certain grapes. The south temperate fruits consist chiefly of the peach, Japanese plum, grape, pear and cherries. Fruits thriving in the north-temperate zone are the apple, pear, European plums, raspberries, blackberry, strawberry, currants, gooseberries and certain grapes. The boreal zone takes in the most northerly region in which fruits grow and all the prairie provinces, excepting a very small area in southern Manitoba, fall into this zone. The fruits grown in this zone are confined largely to certain crab-apples, certain varieties of plums, certain red raspberries, certain gooseberries, currants, certain strawberries and a few varieties of grapes. Certain native fruits, such as the pin cherry, choke-cherry, serviceberry, American cranberry and blueberries are of considerable importance in this region. Those grown in tropical zones have very high temperature requirements and freezing temperatures are never experienced in this zone. Those grown in the boreal zone, on the other hand, represent the maximum with respect to hardiness and these will thrive in very northerly latitudes if given a reasonable opportunity to do so.

Temperature a Limiting Factor.—The limiting factor in the growing of fruits in the Great Plains region is usually temperature. Other factors can usually be modified to meet the demands of fruits but little can be done in ameliorating temperature. Temperatures sufficiently high to be a limiting factor are probably not experienced in this region and only low temperatures limit the variety that may be grown successfully in northern latitudes.

The element of temperature is twofold. It comprises: (*a*) atmospheric temperature and (*b*) soil temperature. When

reference to temperature is made it is usually taken for granted that it is the atmospheric temperature that is concerned and the matter of soil temperature is overlooked. As far as summer temperatures in this region are concerned those of the soil can probably be disregarded, but soil temperatures during the winter have an important relation to fruit growing.

Atmospheric Temperature

Very important considerations in connection with the atmospheric temperature in relation to fruits are as follows: (1) length of the frost free season, (2) mean temperature for the frost-free season, (3) minimum temperatures for the year, (4) time of occurrence of low temperatures and (5) duration of very low temperatures.

Length of Frost-free Season.—To be successful consistently in a given section a fruit must flower, develop and mature during the frost-free season in that section. Frosts occurring either during or after the flowering season are likely to do serious damage to the flowers or to the tiny fruits. Frosts occurring during the season of development may injure the fruits and the new vegetative growth, and frosts occurring before the fruit is mature may damage the fruit sufficiently to render it worthless.

It is impossible to give reliable information as to the dates representing the beginning and the ending of the frost-free period in the Great Plains region. These dates differ greatly. At Saskatoon the frost-free period usually begins about May 20th and usually ends about the first week in September. The frost-free season in this latitude is usually of three and one-half months' duration, but is occasionally confined to three months or less. Farther south this period is longer, while farther north it is usually shorter.

To be dependable in the Saskatoon region, fruits must flower, therefore, not much earlier than May 20th and must mature by the first week in September. In a few cases, however, notably in certain crab-apples and in certain cherries, light frost does not injure the fruit and ripening will continue after the early frosts occur. While useful, the late-ripening fruits are less satisfactory than those that mature early and are likely to prove a disappointment periodically at least.

Much less variation in the dates of flowering than in the date of maturity is found in these fruits. The average date of full bloom for the plums and cherries lies between May 20th

and May 25th and for the crab-apples between May 25th and June 1st.

Mean Temperature for Frost-free Season.—The mean temperature for the frost-free season is of great importance in the growing of fruits. Like other plants, fruits appear to require a certain amount of effective heat to carry them

AVERAGE DATES OF MATURITY OF A FEW VARIETIES OF TREE FRUITS AT SASKATOON

Fruit.	Variety.	Average Date of Maturity.
Plum	Select Seedling	August 15th
,,	Pembina	,, 22nd
,,	Assiniboine	,, 25th
,,	Cree	,, 25th
,,	Underwood	,, 25th
,,	Olson	,, 27th
,,	Mammoth	,, 28th
,,	Cheney	September 1st
,,	Waneta	,, 10th
,,	Winona	,, 15th
Cherry	Opata	August 18th
,,	Tom Thumb	,, 18th
,,	Oka	,, 30th
,,	Champa	,, 31st
,,	Compass	September 6th
Crab-apple	Sylvia	August 12th
,,	Osman	,, 20th
,,	Magnus	,, 25th
,,	Florence	September 1st
,,	Prince	,, 5th
,,	Columbia	,, 10th
,,	Olga	,, 10th

through the various stages of development to maturity. When the mean temperature for the frost-free season is low the period of development may be long, but when the mean temperature for the frost-free season is higher the period of development may be shortened accordingly, provided other environmental conditions are the same. In many cases varieties of fruit that are otherwise suited to a region cannot be grown successfully in that region because of the low mean temperature for the frost-free season. A case in point is found in an unnamed seedling plum that matures its fruit at Saskatoon between August 10th and August 15th, but which does not mature its fruit until September 15th at Lake Majeau in northern Alberta. The Assiniboine plum matures its fruit before the end of August ~~at Saskatoon~~, but fails to

mature it before the end of September at Beaverlodge in northern Alberta.

Various methods of expressing the heat effective in the development of plants have been employed. The usual method, however, is that of selecting what is considered a suitable minimum temperature and totalling the heat units above this. The minimum temperature usually selected is 43° F. If the mean temperature for a given day is 63° F., the effective heat units for that day are 20. If the mean were 73° F., the effective heat units would be 30. If the mean temperature for the month of June were 58° F., the total effective heat units for the month would be obtained by taking 15 units for each day and multiplying this by 30, making a total of 450. This is a very simple method, and is one that has been used extensively in the study of plants in relation to temperature.

The author is taking the liberty of using a special term to express these heat units. The term that will be used henceforth is "degree-day". A degree-day is one degree F. for a period of twenty-four hours above a certain minimum and below the mean for the day. The number of degree-days for a given twenty-four-hour period is determined by taking the difference between the minimum to be used and the mean temperature for that twenty-four-hour period.

It is not questioned that the method outlined is lacking in accuracy. For instance, according to this method the ten degrees between the minimum of 43° F. and 53° F. are just as effective as the ten degrees between 53° F. and 63° F. or as those between 63° F. and 73° F. Such is not the case. Carefully conducted experiments on certain plants show that the amount of increase in development is very much greater where the temperature is increased from 53° F. to 63° F. or from 63° F. to 73° F. than where it is increased from 43° F. to 53° F. The growth rate at 53° F. may be five times that at 43° F.; at 63° F. it may be thirty times that at 43° F.; and at 73° F. it may be 100 times that at 43° F. Nevertheless the system has merit in that it is a practicable means of attempting to evaluate the effective heat during a season or during part of a season and to relate it to development in the plant.

The matter of working out the degree-days necessary for varieties is not as simple as it appears. It is found that the amount of heat required for a given period of development in a plant is not constant. This is shown in the table that follows.

NUMBER OF DEGREE-DAYS REQUIRED BY THE EARLY HARVEST APPLE FROM JANUARY 1ST TO RIPENING OF THE FRUIT IN DIFFERENT SECTIONS OF AMERICA

Locality.	Date of Flowering.	Date of Ripening.	Degree-Days.
Thamesville, Ga.	March 10th	July 10th	4945
Raleigh, N.C.	April 6th	,, 2nd	3157
Rochester, N.Y.	May 21st	August 11th	2743

It may be seen that the number of degree-days required diminishes with an increase in latitude and that the variety in question requires for bringing it to maturity at Rochester little more than one-half the number of degree-days required to bring it to maturity at Thamesville. The temperatures at Thamesville were evidently considerably higher than those required by the variety and much of the heat was without effect in bringing the fruit to maturity.

The number of degree-days from flowering to maturity of fruit for the Assiniboine plum in the season of 1933 using 45° F. as the minimum effective temperature were as follows:

Morden, Manitoba	2382
Saskatoon, Saskatchewan	1925

It has been found also that variations from season to season occur. Values for four varieties of apples and for two varieties of plums appear in the table below.

NUMBER OF DEGREE-DAYS (ABOVE 32° F.) RECEIVED EACH YEAR FROM JANUARY 1ST TO DATE OF FIRST BLOOM IN APPLES (SANDSTEN, WIS.)

Variety.	1902.	1903.	1904.	1905.
Wealthy	810·5	837·5	752·0	690
Charlamoff	837·0	928·0	752·5	713
Hibernal	785·0	837·5	707·0	599
Borovinka	837·0	810·5	727·0	599

NUMBER OF DEGREE-DAYS (ABOVE 45° F.) AND NUMBER OF HOURS OF SUNLIGHT FROM FLOWERING OF PLANT TO MATURITY OF FRUIT IN PLUMS AT SASKATOON

Year.	Mean Temp. June-Aug. inclusive.	Assiniboine.			No. 40-8.		
		Degree-days.	Hours Sunlight.	Date Fruit Ripened.	Degree-days.	Hours Sunlight.	Date Fruit Ripened.
1931	64·0	1527	750	Aug. 19	1527	750	Aug. 19
1932	64·1	1623	775	,, 25	1484	733	,, 20
1933	65·9	1925	941	,, 29	1799	892	,, 23

It may be thus seen that the number of degree-days required by a given variety is not a simple function of temperature. The increases in the mean temperatures shown for the year 1932 over 1931 and for 1933 over 1932 did not hasten the maturity of the fruit and resulted in a greater number of degree-days being required to bring the fruit to maturity. A relation is shown between the hours of sunlight and the number of degree-days as might be expected. Soil moisture is doubtless a factor and the high temperatures recorded during parts of the day may not only be without value to the plant but may be actually harmful. Conditions previous to flowering appear to play a part and conditions obtaining during the autumn previous also may be a factor. In any case the possibilities for the construction of a mathematical formula that may be used in working out values for a given variety appear to be remote at present.

Minimum Temperatures for the Year.—Not less important than the length of and the average temperature for the frost-free season in the growing of fruits are the minimum temperatures for the year. Only an extremely hardy plant will survive without injury temperatures as low as $-40°$ F. Temperatures even lower than this are recorded in certain parts of the Great Plains region and fruits are being grown where temperatures as low as $-60°$ F. have been experienced.

Very low temperatures are destructive to living plant tissue. In the freezing process water is drawn from the cells into the intercellular spaces, where it becomes frozen. This withdrawal of water results in an increase in the concentration of the sap remaining in the cell. As the temperature falls more water is drawn from the cell and the concentration of the cell sap increases further. With a rise in temperature the water withdrawn from the cell, and which was frozen in the intercellular spaces, returns to the fluid condition and is reabsorbed by the cell. In this case no injury from the freezing occurs. If, however, the withdrawal of water from the cell in the freezing process has been carried too far, the concentration of the cell sap reaches a point where chemical action between the concentrated cell sap and certain of the constituents of the protoplasm takes place and permanent injury to the cell results. In this case the water withdrawn from the cell in the freezing process is not reabsorbed in the normal manner with a rise in temperature and much or all of it is lost to the atmosphere. Sudden drops in temperature resulting in a rapid withdrawal of water from the cells, and possibly in the formation of ice within the cell, are likely to be more injurious to the plant

than is a gradual lowering of the temperature where a partial readjustment to the new conditions is possible.

Rate of thawing appears to have no relation to the amount of injury done by low temperatures. While the opinion that rapid thawing increases the amount of damage from low temperatures is frequently expressed, investigations show that the injury is the same whether the rate of thawing be slow or rapid. Light may be detrimental in some cases through opening the stomata and permitting the rapid escape of water from the intercellular spaces before it has returned to the cell. In place of retarding thawing, water sprayed or sprinkled over the frozen plant may increase the rate of thawing but its use is beneficial through the addition of moisture and the reduction in the rate of loss of water through evaporation.

A relation between the rate of air movement and the injury resulting to plants from a given low temperature is found. For animals it has been shown that a decrease in the rate of air movement from twenty-five miles to five miles per hour during the winter was equivalent to a rise in temperature of 19° F. Though less sensitive to changes in the rate of air movement than animals, plants show a reaction to such changes and fruit plants that are protected from winds frequently escape injury from freezing where similar plants that are exposed are seriously damaged.

Plants and their parts differ with respect to their hardiness. Woody plants as a class are hardier than herbaceous plants. Some woody plants are tender while others are very hardy. In many cases the roots of a plant will not endure as low temperatures as will the parts above-ground. This is particularly true in the cases of woody plants. Rootlets are less resistant to cold than are small roots and small roots are less hardy than large roots. The new growth above-ground is more resistant to cold than is the older growth and branches of trees are frequently found with only a thin layer of living tissue around the outside. Branchlets frequently show no winter injury when branches show considerable damage. Flower-buds are usually less hardy than leaf-buds and in certain hardy varieties fruit-buds are produced freely but are destroyed by the low temperatures of winter.

The condition of the plant with reference to maturity influences markedly its sensitivity to cold. A plant in a rapidly growing condition is very sensitive to frost while the same plant may be able to resist much frost after becoming hardened or matured. The increase in resistance to cold

brought about by these changes is not very great in most herbaceous plants but it may be very great in woody plants. When growing rapidly, twigs of certain crab-apples may be severely injured by ten degrees of frost while the same twigs may resist eighty degrees of frost or more during the winter. Apple roots are reported to be killed by a temperature of 26° F. in summer with rapid freezing while the same roots will stand temperatures as low as 10° F. during the latter part of the winter. Woody plants that are fully matured are better able to survive the winter than similar plants that are not fully matured. Where the growing season is short, long shoots frequently fail to mature and plants habitually producing these usually suffer seriously from winter killing. Woody plants that make little growth during the season and produce only short shoots, on the other hand, are likely to mature their wood well and are less subject to injury from the low temperatures of winter than are those that are lavish with their growth.

Time of Occurrence of Low Temperatures.—Two very important considerations in connection with the occurrence of the minimum atmospheric temperatures are: (1) time of occurrence and (2) duration. Low temperatures do the least damage when the plants have reached their most advanced stages of maturity. These are normally reached about or just before midwinter. Earlier than this the conversion of certain compounds in the plant cell that are moderately frost-resistant to compounds that are extremely frost resistant is not likely to be completed and at that time parts of the plant may not be able to withstand very low temperatures. Moderate temperatures during November and December have a marked hardening effect upon the tissues of the plant through favouring this conversion and by January these tissues are best able to resist very low temperatures. As spring is approached and temperatures rise certain other changes take place in the plant and the tissues lose their ability to resist winter temperatures. If the lowest temperatures occur during January or early in February, the minimum amount of injury from freezing is likely to be done, but if these occur much earlier or much later, the amount of injury may be greater, depending upon the maturity of the tissues and the inactivity of the cells.

Duration of Low Temperatures.—The duration of periods of very low temperatures influences greatly the amount of injury occurring from freezing. When a very low temperature prevails for a few hours only, much less damage is done to

fruit plants than when a similar temperature prevails for a longer period. For instance, peaches are not considered a suitable crop for a district where the temperature drops below $-10°$ F., but the author has seen an excellent crop of this fruit harvested after a temperature of $-27°$ F. was experienced. This temperature and temperatures approaching it, which are extreme for that particular section of Canada, prevailed for a few hours only and the plants were not injured. If such temperatures had prevailed for twenty-four hours or more the trees would doubtless have been seriously injured and many of the flower-buds destroyed. While the temperatures of the part of the plant above-ground fluctuate with the atmospheric temperatures, considerable lag in the former occurs and when the fluctuations are rapid the plant never reaches the extreme points, be these low or high. If, on the other hand, the changes in atmospheric temperature take place slowly the temperatures of the plant will follow those of the atmosphere more closely and the lower extremes may result in greater injury in such cases than would occur otherwise.

Soil Temperature

As stated above, winter soil temperatures have an important relation to fruit growing. The roots of fruit plants in general are less resistant to frost than are the parts above-ground and soil temperatures that are damaging to the root system are frequently experienced. Since the part of the plant above-ground is dependent on the part below-ground for its supply of moisture and mineral salts, injury to the root system is usually reflected in the top. Some of the killing occurring in the exposed parts is doubtless the result indirectly of frost injury to the parts below-ground.

Depth of Frost Line.—In the prairie regions frost usually penetrates the ground to great depths. City engineers frequently find the frost line at a depth of eight feet or more and they are forced to place their pipe lines for the transport of water and sewerage at a depth of ten feet at least. The lowest soil temperature is found at or near the ground surface and this may or may not differ greatly from the atmospheric temperature depending upon the amount of ground covering. With an increase in depth the temperature rises and at the frost line it will be found near the freezing point. Penetration is usually more rapid in the lighter soils than in the heavier soils.

Soil Temperatures at Different Depths at Saskatoon.—Minimum soil temperatures obtained in a protected grassed area near buildings at the University of Saskatchewan for the winter 1922–23 are summarized in the table below. The soil in this area was of a heavy type and contained a moderate amount of moisture.

MINIMUM TEMPERATURES, 1922–23

Month.	1 ft.	2 ft.	3 ft.	4 ft.	5 ft.	6 ft.	7 ft.	8 ft.	Atmosphere.
December	8·4	23·4	29·3	34·0	35·6	38·1	39·9	41·0	–27·4
January	10·4	23·4	28·0	33·2	33·6	36·0	37·4	38·6	–27·4
February	–0·6	21·6	25·0	30·0	30·9	33·4	34·9	36·1	–34·6
March	6·8	23·4	25·4	30·4	30·2	31·8	33·2	34·3	–17·5

Considerable difference between atmospheric temperature and soil temperature at a depth of one foot may be noted. The lowest temperature recorded during the winter at this depth was –0·6° F. while the minimum atmospheric temperature was –34·6° F. The soil temperature rose from that at the depth of one foot to higher points as the depth increased and the greatest depth to which frost penetrated in that particular location was six feet. Data for temperatures at different levels in the top foot of soil are not available, but there was doubtless a sharp gradient downward from that at one foot to those at points nearer the surface.

Frost Endurance of Roots.—Since most of the absorbing roots of fruit plants are in the first foot of soil these roots are subjected during the winter to very low temperatures. The fine roots of standard apples are reported to be destroyed during the winter by temperatures around 12° F. Since these are above the minmum recorded at a depth of one foot and consequently considerably above those obtaining near the surface, it may be assumed that most of the fine roots of plants of this apple are destroyed during the winter in this climate. Information relative to the resistance of roots of the Siberian crab-apple and of seedlings of hardy hybrid crab-apples to low temperatures is not available, but these will doubtless endure temperatures lower than those found for roots of the standard apple. According to one authority roots of the raspberry will withstand temperatures down to 11° F.; roots of the currant down to 0° F.; and roots of the gooseberry down to –5° F. Some of these values at least are to be questioned for varieties growing in prairie regions as rasp-

berry plants could not survive the winter if their roots were killed at temperatures below 11° F. Further, this authority found that roots of the sand-cherry were killed at 12° F., which does not agree with prairie experience. These results suggest that tender varieties or tender strains were probably used in some cases at least and an explanation for some of the discrepancies noted may be found in the fact that strains and varieties differ greatly with respect to hardiness. Definite information on the hardiness of roots of the various varieties grown successfully in prairie regions is lacking. It may be assumed, however, that many of the small roots of certain of these fruits at least are usually either seriously injured or killed by low temperatures at some time during the winter.

Soil Temperatures at Winnipeg.—Soil temperatures obtained on the grounds of the College of Agriculture, University of Manitoba, Winnipeg, Manitoba, differ markedly from those obtained at Saskatoon. These measurements too were obtained in a grassed area.

LOWEST SOIL TEMPERATURES RECORDED DURING THE WINTER MONTHS AT DIFFERENT DEPTHS AT WINNIPEG, MANITOBA

Depth.	1929–30.	1930–31.	1931–32.	1932–33	1933–34.
Surface	19·36	23·25	5·44	12·73	5·21
4 inches	20·55	28·62	19·12	19·40	18·12
10 "	22·63	29·68	19·62	22·20	23·85
20 "	25·03	29·76	23·50	23·57	27·47
40 "	29·86	32·02	29·08	27·93	28·95
66 "	31·58	33·18	30·85	31·24	31·06
9 feet	35·03	37·24	35·48	35·45	34·94

While the depths used at Winnipeg do not correspond with those used at Saskatoon, a comparison can be made. As noted before, a temperature slightly below zero F., for a depth of one foot, was recorded at Saskatoon. The lowest temperature at a depth of ten inches recorded during the five years at Winnipeg is 19·6° F. The difference between the temperatures at ten inches and four inches is small, as is also that between the temperatures at ten inches and twenty inches. At Saskatoon the difference between one-foot and two-foot temperatures is great. Even the lowest surface temperature at Winnipeg is nearly 6° F. above the lowest temperature at a depth of one foot at Saskatoon.

Saskatoon versus Winnipeg Soil Temperatures.—An explanation for the differences between Saskatoon and Winnipeg

soil temperatures is easily found. At Winnipeg snow falls early and the ground becomes covered with a good layer of this insulator before the severe weather comes. This blanket of snow remains on the ground throughout the coldest part of the winter and prevents the soil, even at the surface, from reaching low temperature levels. At Saskatoon conditions are different. Frequently little or no snow covers the ground before the end of December or early in January. Prior to the first snowfall very low temperatures are experienced and the frost penetrates to great depths. Even during the latter part of the winter the covering is light and the insulating value of this thin covering is low. During the winter of 1922–23 the ground covering at Saskatoon was light and the frost penetrated the ground rapidly. The ground covering at Winnipeg was sufficient during all five winters to prevent rapid penetration of frost at any time. This was borne out by marked drops in the temperatures at the soil surface in two years following thaws in late winter.

The differences in winter temperature between the soil at Winnipeg and the soil at Saskatoon doubtless accounts in part at least for the differences in the behaviour of certain plants in the two provinces. Soil temperature conditions at Winnipeg are probably representative for a large section of Manitoba and those at Saskatoon are doubtless representative for a large section of Saskatchewan. It is well known that certain plants wintering well in Manitoba winter poorly in Saskatchewan. Since the lowest temperatures found in the first foot of soil in Manitoba are above those generally regarded as destructive to roots of certain fruits, and since the temperatures obtained in a similar layer of soil in Saskatchewan drop below those considered injurious to such roots, the belief that differences in the amount of root killing occurring is a factor is probably fairly well founded. Differences in other environmental factors obtain and these doubtless play a part, but the factor of difference in soil temperature cannot be ignored.

Soil Temperature a Decisive Factor in Fruit Growing.—The matter of soil temperature is thus seen to be a very important factor in fruit growing in northern latitudes. A plant cannot be any hardier than its roots. If the roots are unable to endure the temperatures to which they are subjected, the plant cannot survive no matter how hardy the part above-ground may be. Since the roots of most fruit plants are relatively tender, the soil temperature factor must not be overlooked and must be given the place in fruit studies that it deserves.

WINTER INJURY IN FRUIT PLANTS

Winter injury manifests itself in various forms. The most important forms occurring in northern prairie regions are: root-killing, killing-back in branches, black-heart, sun-scald, killing of dormant flowers and buds and killing of swollen buds.

Root-killing has been discussed briefly under the heading "Frost Endurance of Roots," page 254, and merely means of

FIG. 52.—WINTER INJURY IN A TREE OF THE PIOTOSH CRAB-APPLE
This is not uncommon in trees of Saunders' second generation hybrids in most parts of the prairie provinces.

preventing it or lessening it will be discussed here. It is a very important form of winter injury and one that is too often overlooked. Much of the killing above-ground occurring in fruit plants is doubtless the result of root-killing and of the destruction of many of the absorbing organs of the plant.

The use of hardy stocks is a remedy that immediately suggests itself for this trouble. For the fruits propagated by budding and grafting very hardy stocks are available and these have proved to be suited to the varieties commonly grown. The use of such stocks will do much toward ensuring against root injury and against failure resulting from this form of

frost damage. Raising the temperature in the first foot of soil a few degrees will lessen or prevent much of the root injury occurring. The lowest temperatures occurring in the second foot of soil are usually above the danger point for the roots of plants of most hardy fruits. If, therefore, the temperatures normally prevailing in the second foot of soil are made to prevail in the first foot, where most of the roots are found, root injury will be reduced greatly or prevented in many cases. The use merely of a cover crop and allowing this to lie on the ground over winter has been found to hold the soil temperature of that particular area a few degrees above that where the area was kept clean. While the use of a cover crop is not advisable in many cases in the West, such a crop might be used where a plentiful supply of moisture was assured at all seasons. A ground covering is indicated in all cases and this might be provided through mulching the area heavily, banking soil over the roots and using means to trap the snow. Any one of these three coverings is effective and when present in sufficient quantities they will raise the temperature of the soil to the point where roots that are ordinarily tender may escape injury from low winter temperatures. These must be used in such a way, however, that freezing from the sides will not overcome the beneficial effect of protection from above.

Deep planting is sometimes practised to prevent injury to roots from low temperatures. In certain sections of the fruit-growing areas of America it is routine practice with certain fruits. The aim is to have the roots farther below the surface than they normally are and consequently to have them in a soil with a correspondingly higher temperature. It appears to work well and certain fruits are grown successfully in areas where their growing otherwise would not be possible. For tree fruits, such practice might well be considered in certain sections on the prairies. In light soils, for instance, where the frost penetrates rapidly, such planting might have virtue. In soils provided with abundance of subsoil moisture it would probably be safe practice and in some such cases it would doubtless be beneficial. Its value should be considered doubtful, however, particularly where the annual precipitation is light and where the plants depend largely on the surface layer of soil for their supplies of moisture.

Killing-back of branches is very common in plants of many varieties of fruits. Various degrees of killing occur and even in a given variety considerable difference between the amount of killing-back in one year and the amount of killing-back in another year may be noted. Plants suffering from killing-

back are usually regarded as lacking in hardiness and, while this is true in many cases, it is not true in all cases. This injury is frequently the result of drying during the winter brought about by the inability of the parts affected to obtain from the soil sufficient moisture to balance that lost by evaporation. Where the soil is low in moisture, or where the fine roots have been injured by low temperatures, the plant may be unable to take up the required amount of water. In such a case drying-out of the parts most distant from the absorbing organs takes place, even though the plant is inherently hardy. The amount of killing-back in this case will depend upon the shortage of moisture in the plant. Any condition that favours evaporation, such as rapid air movement, or that impedes absorption will increase the amount of injury. Where moisture is not a factor the killing-back may be due to the lack of inherent hardiness in the plant or to lack of proper maturity of the tissues. In the former case the killing-back is usually severe and frequently reaches the snow-line. In the latter case it may or may not be severe, depending upon the extent of the failure of the plant to mature its wood well.

Various measures for the prevention of this trouble may be employed. Varieties lacking the necessary hardiness should not be grown. The plants used should be given liberal spacings and the soil well tilled to provide for each plant the maximum amount of moisture possible. If necessary the roots should be given additional protection to prevent the destruction of the roots concerned with absorption. Growing the plants in the bush form and providing protection from wind will assist greatly in reducing the amount of this form of winter injury. In certain fruits, such as the raspberry and grape, covering the parts above-ground may be necessary if this type of injury to the canes is to be prevented.

Black-heart is a very common injury in trees of the apple. It may or may not be associated with the killing-back of branches. The heart-wood and part or nearly all of the sap-wood in the trunk and branches are killed and become darkened. Only a thin layer of living wood encircles this darkened cylinder. Organisms of decay gain entrance sooner or later and attack the dead tissues. Eventually the tree becomes much weakened and either the whole tree or parts of it are broken down by the wind. It usually occurs in varieties lacking in hardiness, but may occur in plants of hardy varieties that have not properly matured their wood before winter set in.

This injury can be prevented by planting varieties that possess hardiness in a marked degree and by following good cultural methods. Varieties lacking in the necessary hardiness are never satisfactory in any case and their use is certain to result in an increase in the amount of black-heart in the plantation. Good cultural methods always pay good dividends and in the prevention of this injury they may make no small contribution.

Sun-scald is a very common form of winter-injury in certain fruits. It occurs on trunks and on large branches. This injury is always found on the side most exposed to the sun and on the trunks of trees it occurs on the south side. The area may be three or four feet long in some cases and may be several inches in width. The bark on the areas affected is destroyed and after a time it peels off. The wood below is thus left without protection. In time this wood decays and the part of the plant affected is much weakened.

In sun-scald the bark is destroyed usually early in the spring. Toward the end of March or early in April, when the sun becomes strong, the tissues near the surface on the side of the trunk or large branch exposed to the sun become warm and the cambial cells—a thin layer of cells between the wood and bark—become active. As a result, these cells lose much of their resistance to low temperatures and are destroyed by the sudden drop in temperature and the heavy frosts that occur at night. Owing to the destruction of these cells the bark peels and the wood below is left unprotected.

The avoidance of trunks in tree fruits will reduce the amount of this injury to the minimum and all plants of such fruits should be grown in the bush form. Where trunks are desired for some special purpose, protection against sun-scald may be effected by the use of sun-shields early in the spring. The parts subject to the injury should be shaded by boards or wrapped loosely with a tough light-coloured paper. The use of tar-paper should be avoided as it may, under certain conditions, be responsible for an actual increase in the temperature of the parts that it is protecting.

Plants showing sun-scald should receive treatment. All bark on sun-scalded areas should be removed and the wood exposed coated with a preservative. Coal-tar is an excellent preservative and this may be applied to all the area excepting the edges near the living bark. Since this compound is destructive to living tissues, some preservative that is harmless to such tissues should be used at the margins of the area. White lead paint has good preserving qualities and may be

used for the margins only or may be used for the entire area where coal-tar is not available.

The Killing of Dormant Flower-buds may occur any time during the winter. It usually occurs, however, when the temperatures are extremely low and when these prevail for considerable time. Flower-buds are less hardy than leaf-buds and all the flower-buds on a given tree may be destroyed by low temperatures and the leaf-buds escape uninjured. The author has seen repeatedly, trees of the Pembina plum heavily laden with flower-buds, and presenting promise for a bountiful crop of fruit, open but few flowers and show no injury to the leaf-buds. It occurs chiefly on varieties that are a little too tender for the district in which the plants are being grown.

The only practicable means of preventing this type of injury is that of avoiding varieties that show this tenderness and providing the plantation with proper protection from the wind. Varieties possessing the necessary hardiness are numerous and a slight sacrifice in quality is preferable to a very great sacrifice in quantity. Recommendations regarding varieties made by authorities should be followed at least until such recommendations are shown to be wanting.

The Killing of Swollen Buds occurs occasionally when weather conditions are such as to force bud development early in the spring. A prolonged warm period toward the end of March or even early in April may result in considerable swelling of the buds in certain fruits and unusually low temperatures following this may destroy many of these important structures.

Little can be done to prevent this injury. The use of shelter and the avoidance of a steep southern slope for the fruit plantation will assist greatly, however, in reducing this type of injury to a minimum.

CHAPTER XVIII

THE FLOWER AND THE FRUIT

THE FLOWER

THE flower is primarily for purposes of reproduction. Through the medium of the flower the plant produces seed and thus perpetuates the species. To this end it is specially designed. Various forms occur. In some forms the chances of being able to produce seed are fewer than in others but the design of the flower in every case appears to be such as is best for the species. In some cases the ability to produce seed has been lost but this condition is to be regarded as a retrogressive step in evolution and one that lessens the chances of the survival of the species. Seed production is essential to the welfare of seed-producing plants as a group and the flower serves the important function of permitting the species to benefit from reproduction by this means.

Essential and non-essential Organs of the Flower.—Flowers have both essential and non-essential organs as far as reproduction is concerned. The essential parts of the flower are the male and female reproductive organs. These are usually found toward the centre of the flower. The non-essential parts are the floral envelopes and these lie outside and around the organs of reproduction. In dicotyledonous plants (those with two seed leaves and which are represented by our hardy fruits) the non-essential organs are known as the calyx and corolla. In monocotyledonous plants (those with only one seed leaf and represented by wheat, grasses, lilies, tulips and narcissi) these organs together are known as the perianth.

Parts of the Flower.—The parts of the flower are, therefore, the calyx and corolla (or perianth in monocotyledons), stamens or male household and pistil or female household. In addition to these are the peduncle or stem of the flower and the receptacle, the enlarged end of the peduncle upon which the calyx, corolla and reproductive organs are borne. Where flowers are borne in clusters, as in the apple, the stalk or stem of the individual flower in the cluster is known as a pedicel.

A common type of flower is shown in Fig. 53. This is of

the plum and it has five sepals, five petals, many stamens and one pistil.

The various parts of the flower are arranged in definite order and have their special characteristics. The calyx is the outer floral envelope and it is made up of sepals. The sepals are usually green in colour but in certain cases they are highly coloured and showy. They vary in number but the most common number is five. Next inside the calyx is the corolla. It consists of petals. Petals are usually showy and may be

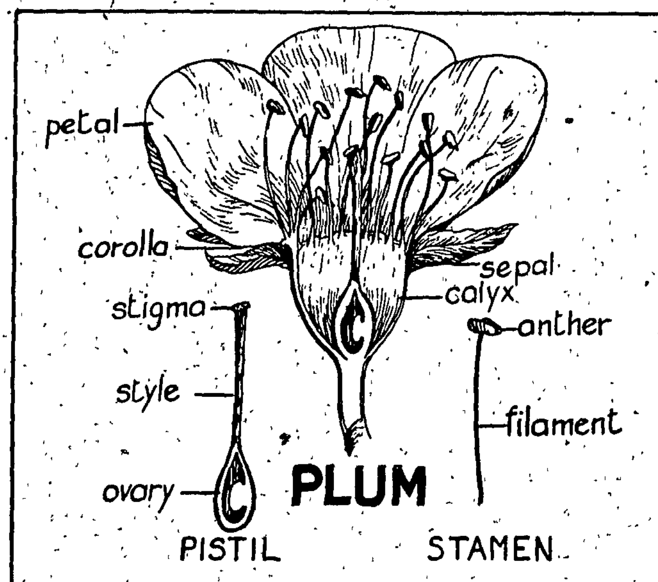

FIG. 53.—FLOWER OF THE PLUM

variously coloured. In some cases they are united while in other cases they are separate. In some plants the corolla is absent and in such cases the calyx is usually brightly coloured. The perianth replaces the calyx and corolla in certain plants as noted and all its divisions are usually showy. Next inside the corolla in dicotyledonous plants and the perianth in monocotyledonous plants are the stamens. These are the male organs of the flower and from three to many are usually present. Each stamen consists of a stalk or filament and an anther which is the enlarged portion at the end of the filament. The anther supplies the pollen used in pollination. Next inside the stamens is the female household or pistil.

In some cases several pistils are found. The pistil consists of the ovary, style, and stigma. The ovary is the enlarged portion at the base of the pistil and it produces the female element that is fertilized by the male element supplied by the pollen grain. Immediately above the ovary is a stalk-like portion known as the style and at the end of the style is a portion that is more or less enlarged and known as the stigma. To this stigma pollen grains find their way through the medium of wind, insects and other agents. When the time is ripe for fertilization this stigma is usually coated with a sticky substance to which the pollen grains adhere.

Bisexual and Unisexual Flowers.—Not all flowers have the two sexes present. A flower with both male and female organs present is perfect or bisexual and such flowers are very common. In certain species, however, two types of flowers are produced. In one type only the male sexual organs are present and in the other type only the female sexual organs are present. Such flowers are imperfect or unisexual. The flowers bearing the stamens or male organs in this case are referred to as staminate flowers while those bearing the female organs are known as pistillate flowers. In certain species the two types of flowers are borne on the same plant while in others the staminate flowers are found on one plant and the pistillate on another plant. In the former the species are said to be monoecious while in the latter they are dioecious.

Flowers of a monoecious plant are shown in Fig. 54. Both the male and female flowers are furnished with corollas and in general appearance they are somewhat similar.

Pollination and Fertilization.—Pollination is the mere transfer of pollen from an anther to a stigma. This may take place without special assistance but in most cases wind, insects and other agents play an important rôle in pollination. Fertilization is the union of the male and female germ cells. It may take place a day or two after pollination but it may be delayed for considerable time. Preliminary to fertilization, pollen grains reach the stigma. If conditions are favourable these pollen grains germinate and send out delicate tubes. These tubes penetrate the tissues of the style growing downward and eventually they reach the ovary. Following the point of the tube downward is the sperm or male germ cell and this germ cell is conducted to an egg that is ready for fertilization. The sperm and the egg unite and fertilization is effected.

THE FRUIT

Fruits are the products of flowers. Without a flower a fruit will not develop under ordinary conditions. Normally the ovary is active in fruit development. In many cases the development of the fruit is dependent upon the fertilization of the ovules and the production of seeds. In other cases the fruit will develop without the fertilization of the ovules and the subsequent production of seeds.

True and False Fruits.—Depending upon their origin, fruits

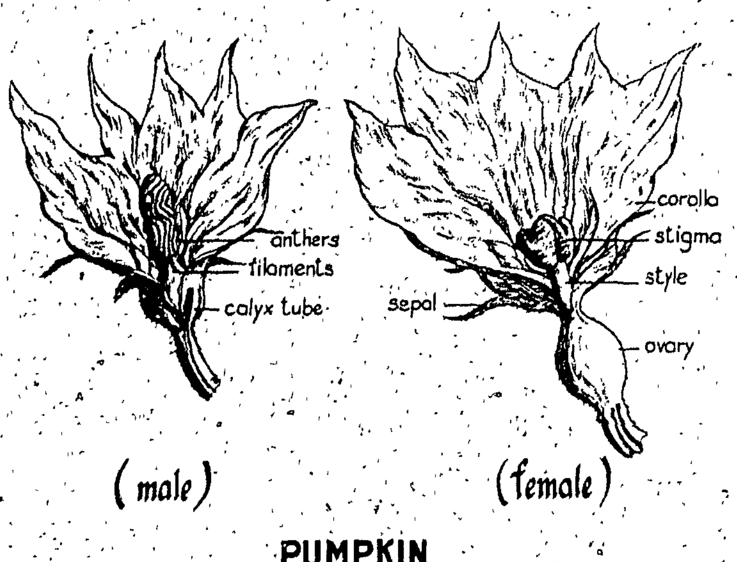

FIG. 54.—FLOWERS OF THE PUMPKIN

are either true or false. In some cases the fruit is the product of the ovary only. Such a fruit is known as a true fruit. In other cases it is the combined product of the ovary and some other part of the flower. Fruits of the latter type are known as false or spurious fruits.

Dry and Fleshy Fruits.—Fruits may be either fleshy or dry. In the former the outer portion of the mature fruit consists of tissues that are more or less juicy and of a fleshy character. In the latter this portion of the mature fruit consists of tissues that are dry, and these may be membranous, leathery, bony or horny in character. Good examples of a fleshy fruit are

found in the plum, cherry and peach. Examples of a dry fruit are found in the bean, hazelnut and corn.

Parts of the Fruit.—A mature true fruit consists of two distinct parts. These are: (*a*) the seed or seeds and (*b*) the ovary wall or pericarp. In some fruits only one seed is found while in others several are present. The pericarp consists of three layers. The outer layer is known as the exocarp; the middle layer, the mesocarp; and the inner layer, the endocarp. In some fruits these layers are readily distinguishable while in others they are not.

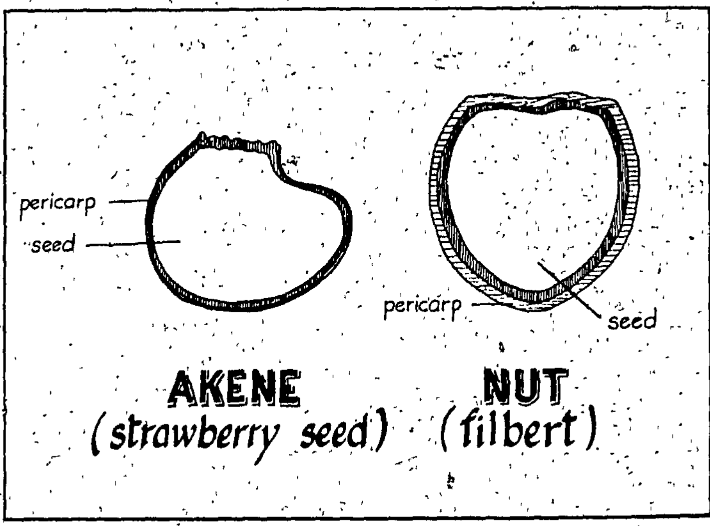

FIG. 55.—AKENE AND NUT

TYPES OF FRUITS

Only the most important types of fruits, particularly those represented by our common hardy fruits, will be dealt with in this chapter. A more complete list will be found in any good textbook on general botany.

(*a*) DRY FRUITS

Akene.—This is a dry one-seeded fruit in which the pericarp is thin and leathery or membranous and does not split open at maturity. Its structure is shown in Fig. 55. The buckwheat is a good example, as is also the seed-like structure on the surface of the fleshy fruit of the strawberry.

Nut.—This fruit is similar in structure to the akene excepting that the pericarp is hardy and bony. The hazelnut or filbert and acorn are good examples of the nut. A hazelnut in section is shown in Fig. 55.

(*b*) FLESHY FRUITS

Drupe.—A drupe is a fleshy true fruit in which the exocarp is thin and skin-like, the mesocarp soft and fleshy and the

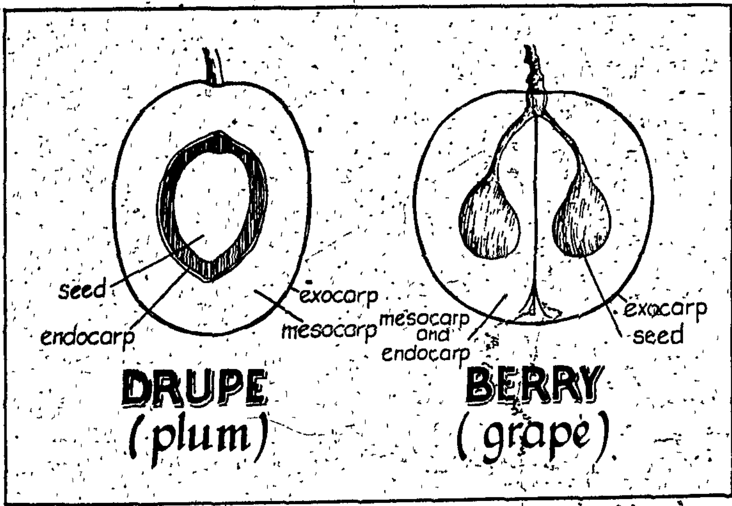

FIG. 56.—DRUPE AND BERRY

endocarp hard and bony. This fruit is usually supplied with either one or two seeds. A typical drupe is shown in Fig. 56. Examples are found in the plums, cherries, apricot, peach, almond and walnut. The pit of the plum, for instance, consists of the seed and the endocarp. In the dried walnut the seed and the endocarp are present, the exocarp and mesocarp having fallen away in the drying process.

Berry.—The berry differs from the drupe in having its endocarp soft and fleshy and in frequently having many seeds. A berry also is shown in Fig. 56. Fruits of the grape, blueberry, tomato, date and banana are typical berries. In the grape, for instance, the seed-like structures are embedded in the flesh and are true seeds. The "stone" of the date is not comparable with the pit of a plum but is a true seed. In the blueberry and tomato the seeds are numerous. The banana

is a seedless berry having developed without the stimulus of seed production.

Pome.—This is a false fruit consisting of a true fruit embedded in and more or less surrounded by a fleshy receptacle. Examples are found in the apple, pear, serviceberry and mountain ash. The arrangement of the parts of the central portion of the fruit is similar to that in the drupe and the receptacle surrounding this portion has stem structure. The order of parts from the centre toward the periphery of the fruit is as follows: seeds, endocarp, mesocarp, exocarp and

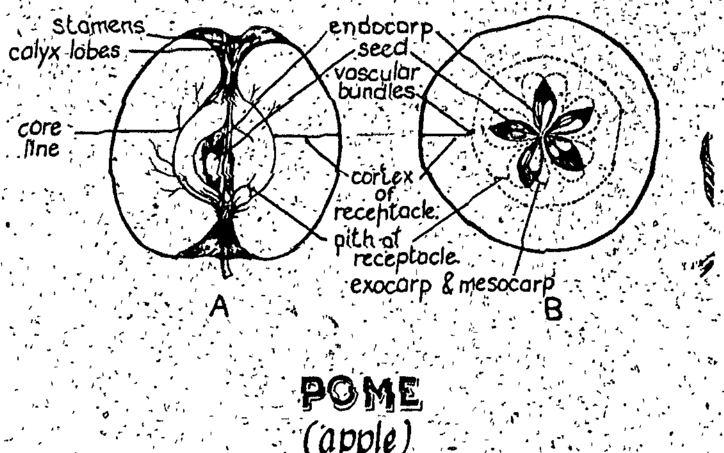

FIG. 57.—THE POME

stem tissue consisting of xylem, vascular ring, cortex and epidermis. The exocarp in the pome is not skin-like as in the drupe but is fleshy, and in many cases the mesocarp, exocarp and xylem are indistinguishable. The calyx usually persists and the remains of the petals and stamens can frequently be seen in the calyx cup of the mature fruit. The details of structure appear in Fig. 57.

Aggregate.—The aggregate is a compound fruit. It consists of a collection of drupelets united by a fleshy supporting tissue and is the product of a single flower with many pistils. Each small section is a drupe consisting of a seed, a bony endocarp, a fleshy mesocarp and a skin-like exocarp and has

developed from the ovary of one of the pistils. In some cases the core, which is the receptacle of the flower, is present in the fruit while in other cases it is absent. While the aggregate is usually classed as a true fruit, it is in some cases, strictly speaking, a false fruit. Examples are found in the raspberries, blackberries, dewberries and loganberries. Fruits of this type are shown in Fig. 58.

Multiple.—In appearance the multiple fruit is similar to the aggregate. It is the product of many flowers, however.

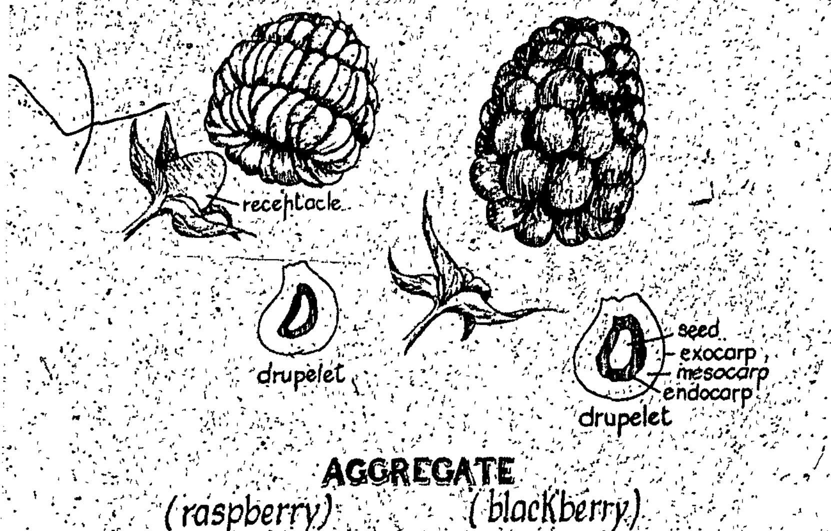

FIG. 58.—AN AGGREGATE FRUIT

Each section in the multiple fruit is a drupelet and is the product of a flower rather than merely of a pistil, as in the aggregate fruit. The fruit consists of parts other than the mature ovary and is therefore a false fruit. The mulberry is a good example of a fruit of this class.

Accessory.—The strawberry is a representative of this group of fruits. The accessory is classed as a false fruit. It consists chiefly of a fleshy portion, which is a much enlarged receptacle, and distributed over the surface of this fleshy receptacle are akenes, a type of dry fruit. Each akene develops from one of the many pistils of the strawberry flower. Even though the akenes make up a very small part of the

fruit, the development of the fleshy part is dependent upon the akenes reaching maturity. Mis-shapen and poorly developed fruits seldom possess the normal complement of mature akenes. The structure of this type of fruit is shown in Fig. 59.

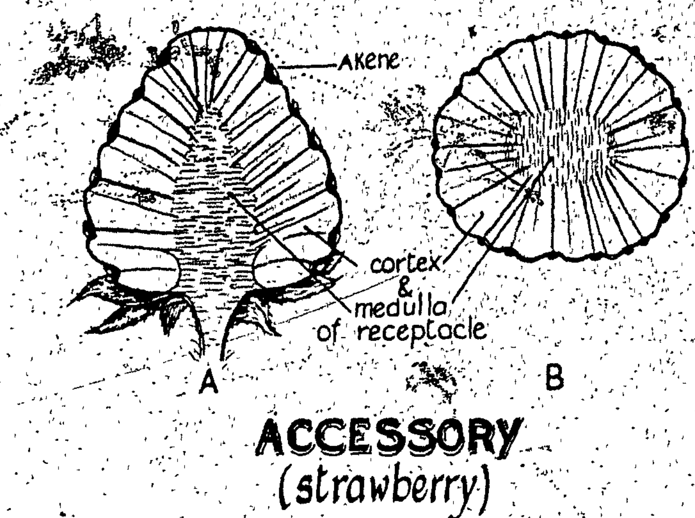

Fig. 59.—An Accessory Fruit

Hesperidium.—This type is not represented in the group of hardy fruits but has representatives in the orange, lemon and grape-fruit. It is a modified berry with a thick leathery rind containing oil glands and a juicy pulp. The number of carpels (divisions of the ovary) is usually greater in this type of fruit than in the berry.

CHAPTER XIX

IMPROVEMENT IN FRUITS

The improvement of fruits has a long history. Records show that great improvement was made in certain fruits before the Christian era. During the centuries following the beginning of this era, plant improvement continued to take place and some of the fruits now in use owe their early improvement to those times. The eighteenth and nineteenth centuries made very important contributions to the improvement of horticultural plants in general and the improvements effected in fruits during this period influenced greatly the horticulture of the past century and is influencing greatly the horticulture of the present day. Marked improvement in many fruits has been made since the beginning of the present century and each year brings its train of improved types and new varieties.

While much has been accomplished in the improvement of fruits in the past, much remains to be done by present and future workers. Until a few years ago the plant improver worked under the handicap of meagre information and the progress made was necessarily slow. With a much greater fund of information on the subject of plant improvement and with a fuller knowledge of the behaviour of plants in breeding, plant improvers of the present and future generations should make rapid progress in this science and should accomplish in a short space of a few years what in earlier times required centuries. Little information on inheritance in fruits is available as yet, but with the additions being made each year to our knowledge of this subject, the fruit breeder should soon be in a position to make rapid advances in the improvement of plants in this class.

Pioneers in Fruit Improvement

Early Pioneers.—Great stimulus to fruit improvement resulted from the early work of Jean Baptiste Van Mons (1765–1842) and Thomas Andrew Knight (1759–1838). The former was a Belgian chemist who set to work with a definite theory to prove, and the latter was an Englishman who without preconceived ideas devoted himself to the study of plants.

Van Mons' Work.—Van Mons believed that the aim of Nature was to produce a vigorous tree and subsequently good seeds to perpetuate the species. Good fruits he regarded as artificial products and the objects of cultivation were to lessen the proportion of the fruit devoted to the production of seeds, and to improve the quality of the fruit. He observed that seedlings of fruits have a tendency to revert to the wild type and this he found more marked in seedlings from old trees than in seedlings from young trees. It was his belief that seeds from young trees only should be used to obtain superior varieties. His practice was to grow generation after generation and his advice was "To sow, to re-sow, to sow again, to sow perpetually; in short, to do nothing but sow is the practice to be pursued and which cannot be departed from". A limit to perfection was found and if attempts were made to go beyond this, poor fruit would be obtained. He found that peaches, cherries, plums and other stone fruits were brought to perfection in three generations from seed, apples in four and pears in five. His most important work was done with pears and in giving certain varieties of pears that are still grown the world over he has demonstrated the great value of selection in fruit improvement.

Knight's Work with Fruits.—Knight was the first scientific breeder of fruits. While Van Mons was making improvements in fruits through selection, Knight was employing cross-breeding as a means of effecting improvement in this class of plants. According to records, Knight was the first to practise hybridization in fruits with a view to variety improvement. He found that greater improvement could usually be made by using seeds that were the result of crossing two varieties than by using seeds that were the result of self-fertilization. His statement in this connection is as follows: "New varieties of species of fruit will generally be better obtained by introducing the farina of one variety of fruit into the blossoms of another, than by propagating any from a single kind". Apples, pears, plums, cherries, peaches and strawberries all yielded to his method of improvement and numerous varieties were produced that were outstanding at that time.

Late Pioneers.—Of the many that have made important contributions to fruit improvement since the time of Van Mons and Knight, few names are better known to the general public in America than Burbank and Hansen of United States and Saunders and Macoun of Canada. These are household names, and the works of these stalwarts have given lasting stimulus to fruit improvement in America and have made a

lasting impression upon the development of fruit growing on this continent. The names of Gideon and Stevenson also should be mentioned for their very important contributions to the development of fruit growing in the Great Plains region of America.

Burbank.—Luther Burbank (1849–1926), who spent most of his life at Santa Rosa, California, was responsible for the improvement and introduction of a great variety of plants. His methods differed from those employed by most plant breeders in that selections were usually made in the early life of the plants. A special faculty, with which he believed himself endowed, enabled him to select outstanding plants in the seedling stage and before fruiting occurred in the cases of fruits.

Improvement in the plum was probably his most important contribution to fruit growing. He brought the Japanese plum into prominence and a number of the commercial varieties of the present day are his introductions.

Hansen.—While not as widely known as the "plant wizard", as Burbank was frequently known, Professor N. E. Hansen of the South Dakota Agricultural Experiment Station, Brookings, South Dakota, is well known in the Great Plains region of North America. His contributions have done much in extending the fruit-growing area in this region. Through hybridizing varieties of the Japanese plum with the Bessey cherry and with the Canada and American plums he succeeded in obtaining varieties of good quality that were adapted to prairie conditions and which are occupying an important place in fruit plantations in those parts. His Assiniboine plum is still regarded as the best hardy plum in cultivation. His Sunbeam, Ohta and Starlight raspberries and his Dakota strawberry are frequently found represented in prairie fruit plantations.

Saunders.—Doctor William Saunders (1835–1914) who was Director, Dominion Experimental Farms, Canada, for the period from 1886 to 1911, made a lasting impression on Canadian fruit development. Perhaps no other man has to his credit the initiation of a project in fruit development as ambitious and as great as that to the credit of Dr. Saunders. Soon after becoming Director of the Dominion Experimental Farm System he realized the need for apples that would prove hardy and would thrive on the plains of western Canada which were being opened and settled at that time. In 1887 the laying of the foundation for the production of such varieties began and this work he continued until his retirement in 1911.

Success attended his efforts and he had the satisfaction and pleasure of extending greatly the apple-growing areas of Canada. To the prairie dweller he gave crab-apples of good size and quality and which possessed all the hardiness necessary for cultivation in the most northerly agricultural sections of Canada.

Macoun.—The most important contributions to fruit improvement made by Dr. W. T. Macoun (1869–1933), who was Dominion Horticulturist from 1910 until his death, were probably the continuation of the project begun by Dr. Saunders and the introduction of certain commercial varieties of the apple. Saunders' varieties were carried through another generation by Macoun. Increases in the size of fruit were obtained but loss in hardiness usually accompanied the increases in size and it is impossible to state at this time what value those varieties will have in the colder parts of the West. Melba is one of the best standard apples introduced by Macoun and is a variety that is becoming important commercially.

Gideon and Stevenson.—Fruit improvement and fruit development in the North-West would not have reached its present stages by this time but for the contributions made by these pioneers. Peter Gideon (1818–99) of Lake Minnetonka, Minnesota, played an important role in laying the foundation for fruit growing in the upper Mississippi Valley. He distributed large numbers of apple seedlings of his own growing and introduced the Wealthy apple. Alexander P. Stevenson (1854–1922) of Morden, Manitoba, was one of the first to establish a fruit plantation on the Canadian prairies. His first plantings in fruit on the prairie were made in 1876. He was the first to produce apples on the Canadian prairies in commercial quantities and his success did much to spread the gospel of fruit growing in that section of Canada. His Mammoth plum is a lasting monument to his faith, courage and enterprise. Certain varieties of apples introduced by him have extended considerably the area in which standard apples may be grown.

Mention might be made of the parts played by many others in this great work. Many have toiled and have made valuable contributions in the improvement of present-day fruits. Space will not permit recording here, however, the splendid work done by this host, visible and invisible, but it may be said that no other group of workers toiled more tirelessly, more unselfishly and with less thought of reward than they.

Need for Improvement in Fruits.—With the many pressing

demands of present-day civilization the need for improvement in fruits becomes great. Products of quality are in greater demand today than ever before and many of the present-day varieties of fruits do not measure up to the standard of quality set by the consuming public of the present time. If the consumption of this class of food is to be maintained or is to be increased, the quality must be improved. Economic conditions demand greater yields and to meet this demand higher producing varieties must be found. Disease has made great inroads on production, and breeding for disease resistance is urgently needed. The desire to push farther back the generally accepted northern limit for cultivated fruits is always present and herein too lie great opportunities for the plant breeder.

The need for new varieties of fruits in the prairie provinces is great. The severe winters, the short frost-free season, the low average temperature during the growing season and the low annual precipitation make special demands upon the plants growing in this region. Varieties of fruits that will thrive under these conditions and that are better than those now in existence are anxiously awaited by a host of gardeners. Extreme hardiness is a prime requisite in perennial plants, and while this is obtainable in many cases, plants possessing the required hardiness are often lacking in other desirable qualities. The combination of extreme hardiness in the plant and of good quality in the fruit in certain cases presents a problem to the breeder of fruits in this region. The short frost-free season results in a demand for plants that will pass through their various stages of development quickly and mature their crops before damage from autumn frost occurs. The low average temperature for the growing season, experienced in prairie regions, necessitates the use of varieties that do not require high temperatures for normal development and the need for varieties of this type is great. Low water requirement in plants is a great asset in the Great Plains area and many varieties that will develop well and yield at least a fair crop in dry seasons are required to round out the list of fruits for this region. These demands all must be met if fruit growing is to occupy the place in prairie agriculture it deserves.

Introduction of Fruit Plants.—The introduction of fruits has been and still is an important factor in fruit improvement. Many of our present-day varieties have been derived from fruits introduced from Europe and Asia. In certain fruits improvement has been wholly dependent on the use of introduced species.

Development of fruit growing in the colder regions particularly will reflect in no small degree the efforts made in exploration and in the introduction of hardy species. Northern Asia and North-eastern Europe have vast areas still unexplored by the plantsman, and these doubtless contain a wealth of valuable material for use in the breeding of hardy fruits. The introduction of some of this would result, not only in the extension of areas capable of producing certain fruits, but also in an improvement in the fruits now grown in the restricted sections of the North on this continent.

Variation in Plants.—Variation in plants is universal. The law of infinite variety prevails throughout Nature. Nature never duplicates and no two individuals are alike in every detail. The difference may be very small in some cases but it is nearly always measurable. A careful examination of the fruit produced on an apple tree, for instance, will reveal that each apple has an individuality all its own and that it differs from all the others in some respects. While appearing much alike in a mass, the flowers of a bed of one variety will show great variation in one or more characters. All down through the myriad species and varieties of plants in existence this condition is found, and the whole plant kingdom is evidence of the existence of that immutable law of endless variation.

Through variation the improvement of plants is made possible. Since differences occur and since variation occurs in all directions, some plants are found to be more desirable than others. In the improvement process the most desirable plants are retained and the least desirable discarded. The most desirable plants are multiplied and are either used for purposes of production or form the basis of material for further improvement of the species.

How Improvement is accomplished

While variations occur in infinite numbers relatively few of these are of particular value in improvement work. Many of the variations occurring are of a minor character and have no definite relation to characteristics desired. Other variations may be desirable but cannot be perpetuated. To be of value a variation must be sufficiently fixed to permit its being carried from plant to plant without loss. Many variations of this type, which might be termed "fixed", are found, and it is these that constitute the new forms and the new varieties that are being introduced by the plant breeder.

(a) Through the Use of Natural "Fixed" Variations

Variations of this type are not uncommon in Nature. These fall into two groups, namely, mutations and bud-sports. It should be understood, however, that all mutations are not natural.

Mutations.—Mutations result from a permanent change in the chromosome constituents of a germ cell which cannot be explained by the laws of segregation and recombination and which are heritable. They are found in Nature and frequently occur in controlled breeding where variations are induced. They arise either (1) as factor mutations or (2) as chromosome aberrations. In the former case a permanent change in one chromosome or more of a germ cell takes place and this change is transmitted to all the descendants of that cell. In the latter case a change in the number of chromosomes takes place. The aberrant forms may differ from their parents in having only one or two chromosomes more or one or two chromosomes less, but in some cases a doubling of the chromosomes results. Other forms of increases in the number of chromosomes also take place. Mutations resulting from a change in the number of chromosomes are much less common and are of much less importance than those resulting from changes in the chromosomes.

Bud-sports.—A special form of "fixed" variation of particular interest to the horticulturist is the bud-sport. Suddenly from a bud of a plant of some variety develops a branch of a form differing from the original in some character or characters. The change may be (1) *progressive* when some entirely new character appears, (2) *degressive* when some partially latent or hidden character appears, or (3) *retrogressive* when an active character becomes latent. The characters of this new form are not heritable in the ordinary sense but they may be sufficiently fixed to permit increase being made by vegetative means. Bud-sports may result either from changes taking place in one chromosome or more in a vegetative cell or from a change in the number of chromosomes in such a cell. From a cell suffering this change the sport arises.

Bud-sports occur frequently in Nature. At one time they were thought to be exceedingly rare but recent studies have revealed their abundance and indicate the likelihood of many having been overlooked in the past. They are found in plants of various types and, while occurring chiefly in plants normally propagated vegetatively, they do occur in plants propagated

by seed. In certain fruits this type of variation is very common and certain varieties owe their origin to such a departure in the type. Systematic searches for such variations are now made by certain horticulturists and some authorities contend that this is a fertile field for investigation. The genus *Citrus*, to which the orange, lemon and grape-fruit belong, has provided many variations of this type and a few have been found among fruits of the cooler parts of the Temperate Zone.

(b) Through Induced Variations

Natural variations usually fall short in filling the needs of the plant improver and variations must be induced. Inducing variations and the selection of certain of these becomes, therefore, one of the chief aims in plant breeding. While variations have been induced through the use of special rays and by other special means, the most important methods of inducing these in plants are (1) by hybridization and (2) by self-fertilization.

Hybridization.—Hybridization may be defined as the combination in a new generation of the characteristics of two plants that are distinctly different in genetic constitution. A hybrid is an individual of the new generation resulting from this combination. Varieties, races, species and even genera in some cases may be hybridized. The term "crossing" which is frequently used synonymously with "hybridization" is usually restricted to the making of combinations within a variety. For instance, the use of pollen from the flowers of one tomato plant on flowers of another plant of the same variety would be "crossing". In this case the two plants in question are not unlike genetically. The use of pollen from the flowers of a tomato plant of one variety on flowers of a tomato plant of another variety, on the other hand, would be "hybridization" because the two varieties are very different genetically.

The production of variations is easily accomplished by hybridization. With an ideal in view the plant breeder hybridizes certain plants which are believed to be capable of supplying suitable variations. Each plant has its set of characters and these characters are represented in the male elements, produced by the pollen grains, and in the female elements, produced by the ovaries, that unite and give rise to new plants. These characters are represented in the elements in different proportions and no two male elements of a given plant may be identical in this respect. This applies to the female elements also. In hybridization, therefore, the various characters of the two plants selected as parents may

become combined in a great many different ways and no two plants of the resulting generation are likely to be the same. A combination that will give the characteristics desired in a plant may be effected in many cases, however, if the number made is sufficiently great. The more hybrids obtained and grown the greater are the chances of success in many cases at least in producing the combination desired. In many plants, hybrids should be produced in tens of thousands if progress is to be assured.

Self-fertilization.—In self-fertilization the male parent and the female parent are one and the same. Where propagation is by seed, pollen from a given plant must be used on flowers of the same plant if self-fertilization is to take place. Where propagation is solely by vegetative means the pollen from a given plant may be used on any plant of that particular variety. In the tomato, for instance, self-fertilization would result only when pollen from a given plant was used on flowers of the same plant. In this case cross-fertilization is possible within the variety. In the apple, on the other hand, where increase of named varieties is made by vegetative means, such as by budding and grafting, self-fertilization may result when pollen of a tree of a variety is used on flowers of any tree of that variety. Cross-fertilization within the variety in this case is impossible because all trees of a given variety in existence are identical in genetic make-up. The original tree only of a given variety was produced by seed and all others are virtually a part of the original tree without change and without the addition of any characters. The addition or subtraction of characters in such a variety is normally made only through hybridization and through the interaction of the characters of another variety. Since this is precluded by vegetative propagation all individuals within the variety are identical and remain as one. This is excluding, of course, the changes in the characters of part of a plant that occur occasionally in bud-sports and that may be made in certain cases by special treatments.

Marked variations can frequently be produced by self-fertilization. Under certain conditions this method is desirable. In plants that are not ordinarily propagated by seed and which must be propagated vegetatively to retain the variety, self-fertilization results in a regrouping of the characters and often in the production of marked variations. Some of these variations may be desirable for immediate use or for use in further breeding work.

Certain Combinations not possible.—It must not be assumed

that any combination of characters is possible. To be combined successfully characters must be compatible. Certain characters are found to be incompatible in certain plants and when attempts are made to combine such characters failure results. Little information on the compatibility of characters in fruits is available and, until more work has been done on this class of plants, the fruit breeder must feel his way and must not be too certain that the combinations he desires can be effected.

Linkage also may be a barrier to the combination of certain desired characters. Frequently characters are not inherited independently. One character may normally be transmitted to the offspring in combination with some other character or characters. Attempts to obtain certain combinations of characters independently may thus be fruitless.

Physical Basis of Fixed Variations

Two types of cells are found in the plant. These are known as the vegetative or somatic cells and the reproductive or germ cells. The former are very numerous and make up the body of the plant. The roots, stem, leaves and most of the parts of the flower all consist of vegetative cells. The latter are usually present in great numbers but are confined to very restricted parts of the flower. The male germ cell is known as the sperm and it is produced by the pollen grain. The female germ cell known as the egg is produced in the ovary by an ovule. In the ordinary course of events the sperm and the egg unite and provide a starting point for the new plant.

Chromosomes in Heredity.—As was stated in Chapter XV, each living plant cell possesses a nucleus. This nucleus is a very important part of the cell and contains certain structures that are the bearers of heredity. These structures are known as chromosomes. In the chromosomes lie all the factors that determine the character of the plant. In the chromosomes of the Osman crab-apple, for instance, are the factors that determine all the characters of the variety. Some of these factors are located in one chromosome and other factors are located in other chromosomes. Each species has its characteristic number of chromosomes, though varieties sometimes differ with respect to the number they possess. Most varieties of the apple, for instance, possess thirty-four chromosomes in their somatic cells, though some have fifty-one. Certain cherries have sixteen and others have thirty-two; certain plums have sixteen, others thirty-two and

others forty-eight. These chromosomes vary greatly in shape but they are usually rod-like structures. In size they are very small and can be seen only with the aid of a high-power microscope. They are distinguishable individually only at certain stages of cell division.

Chromosomes in Cell Division.—Cell division plays an important part in plant growth. Cells divide and redivide. When a cell divides, the nucleus of that cell suffers division. In the division process of a somatic cell each chromosome splits lengthwise, and one-half of each chromosome goes to each of the two daughter cells. Since the two halves of a chromosome are identical, the daughter cells possess the same factors or character determiners as the mother cell. This process continues until increase in the number of cells ceases. All somatic cells of a plant therefore are identical as far as their chromosome complements and character determiners are concerned.

Division of the chromosomes takes place in a different manner in the germ cells. In the sperm and in the egg the chromosome number is normally one-half that in the somatic cell. From one mother cell containing the full complement of chromosomes two daughter cells are found. In this case, however, splitting does not occur and whole chromosomes pass to the daughter cells. This results in each daughter cell possessing only one-half the normal number of somatic chromosomes and since no two chromosomes are alike the daughter cells are unlike with respect to their chromosome make up. The daughter cells thus formed divide but in this case splitting of the chromosomes occurs as in the division of somatic cells and no further reduction in the chromosome number takes place.

Restoration of Chromosome Number in Fertilization.—When fertilization takes place the normal number of chromosomes is restored. The egg with its reduced number of chromosomes and the sperm with its reduced number fuse in fertilization and the cell resulting possesses the chromosome complement of the somatic cells. This cell is the beginning of the new plant. Following a long series of cell divisions, with this cell as the starting point, a new plant results. In the first cell are all the factors determining the character of the plant that is to follow and these factors are passed on to each new cell formed. As a result all the body cells of the plant have the same character determiners and these give expression according to the environment.

Many Combinations of Chromosomes and Germ Cells

possible.—Fundamental differences in the characters of plants grown from seed is the result chiefly of differences in the germ cells that produced those plants. Great variety is found among germ cells of plants usually propagated vegetatively and this is responsible for the presence of marked variation in seedlings of such plants. In the McIntosh apple, for instance, there are 131,072 different possible combinations of groupings of chromosomes in the germ cells. If this variety were crossed with another variety of apple in the same chromosome number group, 129,407,463 different combinations of germ cells would be possible. This means that a given combination of germ cells in this case would be duplicated in more than one hundred and twenty-nine million seedlings only. If these varieties had only seventeen characters and these characters were so distributed that one was carried by each of seventeen chromosomes, 129,407,463 different kinds of seedlings from such a cross would be possible. This number is increased greatly, however, because of the presence of more than one character in a chromosome and because of the exchange of material that takes place between pairs of chromosomes during the formation of germ cells.

Technique in Breeding

In order for fertilization to take place pollen grains of a compatible variety must be placed on the stigmas of the flowers of the plant to be used as the female parent. This transfer of pollen is known as pollination. In Nature this transfer of pollen is accomplished by insects and wind chiefly. Of the two, insects are by far the more important. In Nature pollen of several varieties may be carried to a given plant and pollen of more than one variety may be applied to the stigma of a given pistil.

Controlled Pollination.—In all breeding work complete control of pollination is desirable. In certain cases this is essential. Where inheritance studies are being made, complete information concerning the parents adds greatly to the value of the study and, even where the practical results constitute the chief aim in the breeding project, knowledge of the parents is of value as a guide in further breeding work. In studies of seedling plants accurate knowledge of the parents is indispensable.

If pollination is to be controlled, the natural transfer of pollen to flowers that are to be used and the contamination of the pollen being employed must be prevented. Insects

must be prevented from visiting the flowers to be used in the case of insect-pollinated plants, and in wind-pollinated plants the female flowers to be pollinated by hand must be protected against drifting pollen. Bisexual flowers must be free from their own pollen at the time of pollination if contamination of the pollen for application is to be prevented. These are accomplished by emasculation in the cases of bisexual flowers and by bagging in all cases the flowers to which the pollen is to be applied. The emasculating must be

FIG. 60.—EMASCULATING AND BAGGING FLOWERS IN THE APPLE
Hybridization with controlled pollination is a necessary part of breeding work. This plant of Siberian Crab is being used as a female parent; varieties of standard apples are used as male parents.

done before the anthers release the pollen and bagging is necessary before the flowers open.

Steps in Technique.—While each type of flower may require some special form of technique, the general technique for all flowers is much the same. The technique used in the apple by the author and his associates which is representative for a large group of horticultural plants will be outlined here.

The steps in this technique are as follows: (1) emasculation and bagging; (2) preparation of pollen; (3) pollination and rebagging; (4) unbagging; (5) harvesting the fruits; (6) removal of seeds.

In the apple the flowers are borne in clusters of from five to ten. These clusters appear on short spurs along the branches and at the tips of the branches in certain cases. Each normal flower consists of five sepals, five petals, many stamens and five pistils. All the parts of the flower are readily distinguishable and are readily separated, though the stamens are clustered closely around the pistils. In most varieties the pistils rise above the stamens and their terminal portion may be seen after the petals have been removed.

Emasculation and Bagging.—The emasculation must be done before the flower-buds open. The ideal time for performing the operation is from twelve to twenty-four hours before the flowers are due to open. Since the flowers in the apple are borne in clusters and since considerable variation in the time of opening of the flowers in a given cluster is found, some buds are emasculated from two to three days before they would normally open. In this fruit the central flower of the cluster usually opens at least twenty-four hours before any of the other buds in the cluster open, and it may be advisable in some cases to defer the operation until after the first flower has opened. In such a case the central flower which has opened is removed and only the unopened buds utilized in the breeding work.

The operation consists in removing the petals and the stamens. The petals are removed to permit free access to the stamens and to facilitate pollination at a later date. The removal of the sepals with the petals appears not to be harmful, provided the tube of the calyx, which is closely attached to the ovary, is not injured in the operation. For the beginner at least it is a safer practice to remove the petals only. The petals and stamens can be removed readily with tweezers having sharp and curved points. The parts to be removed are taken between the points of the tweezers and are merely pulled away. Great care must be exercised in performing the operation to prevent injury to the pistils.

The flowers to be emasculated should be at or near the ends of the twigs that are readily accessible. Such flowers can be worked more easily than those nearer the central portions of the tree. Several flowers in a cluster may be emasculated and a few clusters very close together can frequently be worked to advantage. In such cases the clusters should be sufficiently near one another to permit the covering of all with one paper bag.

Immediately after the desirable buds in the cluster or clusters have been emasculated and the undesirable buds

removed the bagging should be done. Bags of "Kraft" paper are very satisfactory for this purpose, and those of the two-pound size are the most suitable for use with apples. In certain cases those of the one-pound size might be adequate. Ordinary paper is much less durable than "Kraft" and bags of it should not be used where accurate work is to be done. The bag is placed over the end of the twig carrying the emasculated flowers and its neck is tied tightly around the branch with common tying cord. The neck of the bag must be brought sufficiently close to the branch to prevent the entrance of pollen carriers.

Where self-fertilization is desired emasculation may or may not be necessary. Hand pollination is advisable in most cases, however. In the flowers of certain plants the petals and stamens may not interfere with hand pollination and in such cases emasculation can be omitted. In the flowers of many plants, however, these parts interfere with the application of pollen by hand and should be removed to permit free access to the pistils. In the former case the removal of opened flowers and bagging only are required while in the latter case the complete treatment outlined above is given.

Preparation of the Pollen.—Large plump anthers are chosen as a source of pollen. These anthers are taken from buds about to open and are placed shallowly in an open dish in a warm room. A room where the atmosphere is dry and the temperature is near 70° F. is very satisfactory for the drying of the anthers. Under such conditions the anthers will usually open and release their pollen grains inside of twenty-four hours. If the temperature is lower or if the atmosphere is somewhat moist, a longer period may be required for the preparation of the pollen but the operator can nearly always depend upon the pollen being in good condition for use in two days from the time the anthers are gathered. It is good policy not to delay the collection of the anthers that are to supply the pollen required, after the emasculation of the flowers on which the pollen is to be used. To keep well, pollen must be dry and that being held even for a short time should be stored in a dry place.

Pollination.—The operation of pollination is carried out from two to three days after emasculation. At this time the bags placed over the emasculated flowers at an earlier date are removed and the pollen applied. The pollen to be used should be in a dry condition and should be viable. The most convenient and economical method of applying the pollen to the stigmas found is that of placing the pollen in a small

shallow vessel, such as a petri dish of small diameter, and bringing the stigmas in contact with the pollen in this container. This usually involves bending the twigs and also the flower-stems, but this can be done safely. At this time the stigmas should be receptive and should be sufficiently coated with a sticky substance to pick up hundreds of pollen grains. Immediately after all the flowers previously covered by a given bag have been pollinated the bag is replaced and tied securely.

The pollen for use should be in as fresh a condition as possible. In the apple, pollen two months old has been found to be viable and in certain plants pollen one year old or more has given good results, but aged pollen should not be used unless it is known to be viable. Conditions of storage have an important relation to longevity in pollen and in the cases cited the pollen was stored under very favourable conditions.

In many plants the steps in self-pollination are the same as those in cross-pollination. The pollen is prepared as outlined above and the flowers that were emasculated and bagged two or three days previously are pollinated individually. After being pollinated they are rebagged.

A less troublesome but much less effective method of self-pollinating is that of bagging the clusters without emasculation before any of the flowers have opened. About twenty-four hours after the flowers open the branches bearing the bagged flowers are jarred vigorously. This is repeated one or two days later. The assumption in this case is that some of the pollen of a given flower will be transferred to the stigma or stigmas of the same flower. This method has been employed on the apple by the author and his associates and fair results have been obtained from its use.

Unbagging.—In from ten days to two weeks after pollination has been effected the bags replaced to protect freshly pollinated flowers are removed. Further protection from probable insect visitors is not necessary and conditions obtaining in the bag are not favourable for the normal development of the fruit.

Use of Bags to protect Fruits.—In certain cases the use of porous bags on the trees to preserve the fruits approaching maturity is advisable. Fleshy fruits in particular are subject to various hazards and the presence of a bag will, in some cases at least, prevent the disappearance of the fruit. Small bags made of cheese cotton are desirable as they permit a free circulation of air and do not induce the development of very abnormal conditions in close proximity to the fruit. Even

"Kraft" paper bags may be used, though the temperature in such bags tends to rise to a point several degrees above that of the surrounding atmosphere when the sun is shining. These bags are placed over the fruit in the same manner that bags were placed over the flower clusters and should be used as soon as the fruit begins to show signs of ripening.

Harvesting the Fruits.—As soon as the fruits have matured, harvesting is carried out. Nothing is to be gained by delaying the operation unduly and loss may result from the dropping

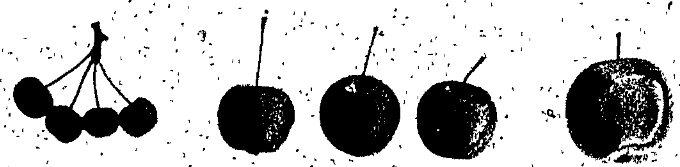

FIG. 61.—THREE GENERATIONS OF APPLES

Siberian Crab Pioneer Selfed Seedling of Pioneer

Siberian Crab is one of the parents of Pioneer.

of the fruit or from the opening of the fruit and the dropping of the seeds. Fleshy fruits should be stored in a cool place and dry fruits should be spread out thinly in a suitable container and stored in a warm place to complete the drying. When opportunity offers at a later date, the seeds, or the seeds with some additional part, are removed from the fruits and given the treatment indicated by investigational work and experience.

Seedlings observed.—The seeds obtained in self- and cross-fertilization are sown and the plants grown. These plants are then subjected to a series of observations and the selections

made. Those considered desirable are preserved and propagated while those considered undesirable are discarded.

Not infrequently are seeds bought or taken from fruits obtained on the market and sown. Such seeds are from uncontrolled pollinations but occasionally give rise to a desirable variation. Seeds taken from fruit of a variety that is considered a good parent are more desirable for use than those from unknown parents. In this case too the plants must be grown until the observations that are to form the basis of selection can be made.

In the cases of plants grown for their fruits, elimination of seedlings should be delayed until fruiting occurs where possible. As far as is known at present good size and quality in the fruit are not definitely associated with any plant characteristic. The plan of discarding seedlings because they have characteristics that are usually associated with small or poor fruit, therefore, is neither safe nor sound practice.

Results of Breeding

Tangible results of breeding in fruits may be found on every hand. Most of the varieties under cultivation are the result of effort in plant improvement work. Many of these are merely selections from seedlings from natural crossing and hybridization but many others are from controlled matings.

Improvement from Controlled Matings.—Good examples of plant improvement from controlled matings are found in our common fruits. Improvement in size and quality of fruit without much decrease in hardiness in the plant has been made in the Siberian crab through hybridization with certain standard apples. Osman, Columbia, Pioneer, Sylvia and Magnus are examples of such hybrids and these fill a very important place in fruits for the prairie provinces. The Pembina, Cree, Radisson, Waneta, Underwood and Minnesota No. 56 plums are a great improvement over the native plum, which is one of the parents in each case. The Opata cherry is infinitely superior to the native Bessey cherry, one of its parents, and the parent from which it obtained its hardiness. The Sunbeam raspberry is a decided improvement over the native raspberry and possesses more hardiness than Shaffer's Colossal, which is the other parent. In the fruit of the Dakota strawberry much greater size is obtained than is found in that of the wild strawberry of the Great Plains region, which is the female parent. In the gooseberry, Pix-

well and Abundance are a great improvement over the Missouri gooseberry. Plants of the former varieties are hardy and the fruits are of good quality and are at least twice the size of the fruits of the latter. The Diploma, Red Cross and Fay's Prolific currants are good examples of superiority over previously existing varieties in this class of fruit. Many other cases could be cited where controlled matings resulted in improved varieties or in varieties that were better suited to

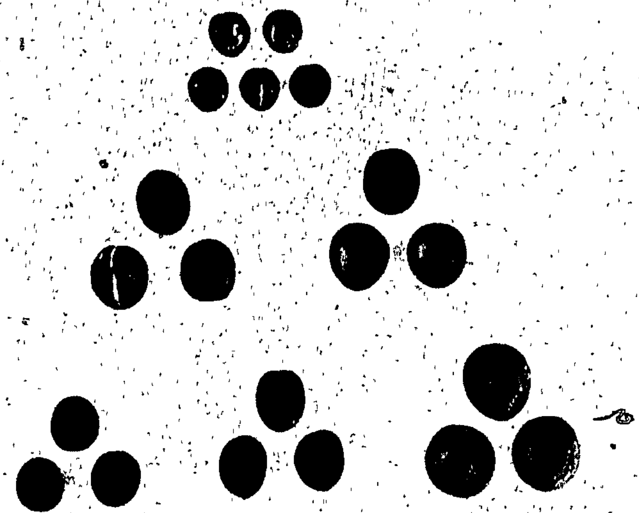

FIG. 62.—UNIMPROVED VERSUS IMPROVED PLUMS

certain special conditions than varieties formerly existing, but these few will serve to illustrate the progress made through this form of plant improvement.

Improvement from Non-controlled Matings.—Improvements from non-controlled matings in fruits are numerous. Most of our varieties of the standard apple are from unknown matings and are merely chance seedlings. The McIntosh, for instance, which is the most popular apple grown in Canada at the present time, is a chance seedling, neither parent being definitely known. Florence, Adam and Dolgo crab-apples, all of which are valuable, are from uncontrolled matings.

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According to Hedrick and Wellington of Genova Station, nearly all of the three thousand varieties or more of the apple that have been described have come from chance seedlings. Of the six hundred and ninety-eight varieties described by Beach in the *Apples of New York*, even the seed parent is known in the cases of thirty-nine only. In plums, Assiniboine, Olson, Mammoth and Cheney are decidedly better than the wild forms native to the West, yet they are seedlings of one of the native species with only the female parent known. The Champa, Oka and Tom Thumb cherries, in each case of which only one parent is known, all are a great step forward in the improvement of the native Bessey cherry. The Herbert raspberry, which is a chance seedling and whose parents are not known definitely, has been classed as the best red raspberry grown in Canada. The Senator Dunlop strawberry, which is a seedling of unknown origin, ranks high among varieties of this fruit and possesses hardiness in a marked degree. The Alpha and Beta grapes show marked improvement over the River grape, one of the parents. Many other representatives of this group might be mentioned but the examples given are sufficient to show the great importance of selection from unknown matings in plant improvement work.

Methods that will be employed in Great Plains Region.—Improvement in fruits for the Great Plains region will be made both through the agency of controlled matings and through the growing of seedlings where only one or neither parent is known. Records to date probably show a balance in favour of controlled matings. It is true that varieties of very great value have been obtained from seedlings of uncontrolled matings but the varieties that made the foundation for further improvement work in fruits for northern sections and that demonstrated the possibilities in the development of hardy fruits are from controlled matings. Both methods, however, offer wonderful opportunities to the plant improver. Most of the seedlings from uncontrolled matings will be grown by individuals who are prepared to nurse a few plants until the fruiting age arrives in the hope that one will prove to be more desirable than any previously existing plant. Seedlings from controlled matings will be grown chiefly by Government employees at Government stations and by a few growers who have plant-breeding as a hobby. Both groups of workers will make important contributions to pomology through the introduction of better varieties and great advances in the improvement of hardy

fruits from the West may be looked for during the next two or three decades.

Growers of seedling fruits must not expect the improbable, however. The chances of a grower of twenty-five or fifty seedlings obtaining an outstanding variety are probably one in five hundred or one in a thousand. This is particularly true in the cases of seedlings from uncontrolled matings. Even though the odds are great the effort is worth while. It is certain that seedlings will be grown in large numbers and that outstanding varieties will be found. Any grower of seedlings may find the "one in one thousand" and be fortunate enough to have the privilege of naming and introducing a variety that will mark a great advance in fruit growing. The "Million Dollar Apple", to which the late G. F. Chipman frequently made reference, may be found among a lot of a dozen seedlings. The growing of fruit seedlings should be regarded as a game of chance, however, where the stakes are high but where few of the many players can win.

CHAPTER XX

PROTECTION OF FRUIT PLANTS AGAINST INJURY BY PESTS AND DISEASES

PESTS and diseases take a great toll in fruit annually. In the fruit-growing sections of the East and of the Pacific Coast scores of pests and diseases are present and the grower must continually offer resistance to their attacks if his crop is to be saved. Even with this constant vigilance and effort the grower suffers losses and in some cases, where thoroughness in the application of the special measure being used is lacking, heavy losses occur. Such enemies are less numerous in prairie sections than in the older parts of Canada, but even here considerable damage occurs each year through neglect on the part of the grower.

Much of the loss occurring each year can be prevented. Through the study of the pests and diseases concerned and the application of special measures designed for their control, the grower can reduce further these unnecessary losses. Exactness, timeliness and thoroughness, all are essential, but with these even the beginner in fruit growing can readily combat these unwelcome guests.

PESTS AND THEIR INJURIES

Pests attacking Fruit Plants.—Most of the ordinary pests attacking fruit plants are insects, though certain allied forms that are not true insects frequently do considerable damage to such plants or their parts. Insects undergo remarkable changes in form during their life-histories and the ugliest-looking worm that feeds on a plant may become the most beautiful creature as an adult, as exemplified in some of the moths and butterflies. Some have three distinct stages in their life-histories while others have four. The stages in the former case are: egg, nymph and adult, and examples of this type are found in plant-lice and grasshoppers. The stages in the latter case are egg, larva, pupa and adult, and examples are found in cutworms, armyworms, wheat-stem sawfly and tent-caterpillars. The nymph is similar to the adult in general form, but in the nymph the wings are either absent or not fully developed. The larva is very unlike the adult and is

sometimes referred to as a worm; in other cases as maggot; and in other cases as a caterpillar. The adults of most of the common injurious forms are either flies, sawflies, beetles, moths or butterflies. In all cases the adults have six pairs of legs, one pair of antennae or feelers and usually wings. Some have two pairs of wings while others have only one pair. The most common allied form doing damage to garden plants is a spider-mite. This is a very small pest with four pairs of legs and without either wings or antennae.

Stages in which Injury is done.—Injury to plants is done by insects in the larval, nymphal and adult stages. In most cases an insect does damage in one stage only but in a few cases injury is done by a given pest in two stages. Examples of insects doing injury to garden plants in the larval stage are found in canker-worms, tent-caterpillars and the imported currant worm. The adults in these cases are quite harmless to plants directly. A few doing damage in the nymphal stage are: plant lice, thrips and grasshoppers. In these cases damage is done by the adults also. Examples of pests doing injury as adults only are found in flea-beetles and blister-beetles.

Types of Injury from Pests.—Pests damage plants by different means. The chief types of injury done are through (1) eating the foliage or some other tissues of the plant, (2) sucking the juices from the tissues, (3) injecting into the plant or its parts substances that are toxic to the plant. Pests doing the first type of damage have biting mouth parts and actually eat some of the tissues. In some cases plants are completely defoliated by such pests and are greatly weakened as a result. Those doing the second type of damage have piercing and sucking mouth parts. These pests force the very fine and needle-like portions of their mouth parts into juicy tissues and then suck the juices from those parts. The parts attacked are deprived of some of their sap and the loss of this, together with the tissues damaged, usually brings about a condition from which the plant suffers seriously. Pests responsible for the third type of injury have piercing and sucking mouth parts also and feed on the juices of the plant. In addition to extracting some of the plant's juices, they introduce toxic substances into the plant. The plant reacts in various ways to these substances, but in all cases, where the infestation is marked, lack of thriftiness is evident. If steps are not taken to control the pest in this case, death of the plant or of the part concerned usually results.

It is evident that a knowledge of the life-history of the insect and a knowledge of the insect's mouth parts are

necessary before control can be undertaken intelligently. It must be known what the injurious stage of the pest is and when this stage will appear. The nature of the pest's mouth parts and how the damage is done must be known if the maximum progress is to be made. For one type of pest a certain agent may be used successfully in control but for another type of pest an entirely different agent may be necessary if the control measure is to be effective.

Diseases and their Injuries

Plant disease is usually referred to in America as an abnormal condition arising in the plant as a result of the presence of certain organisms or other agents or as a result of the absence of certain elements necessary for the normal life processes of the plant. Diseases in plants may be caused by (1) certain fungi, (2) certain bacteria, (3) certain viri and (4) nutritional disturbances. The first three are transmissible while the last is not.

Fungous Diseases.—Diseases caused by fungi are known as fungous diseases. Fungi are a group of lower plants that lack green colouring matter and are unable to manufacture their own food. Roots, stems and leaves are lacking but they ordinarily consist of (1) a mycelium and (2) a sporophore. The mycelium is a feeding body composed of minute white threads that ramify over and through their hosts or the decaying materials on which they grow. The sporophore appears at the surface or above the surface and develops the reproductive organs in the air. There are two general groups of fungi: (1) saprophytes and (2) parasites. Saprophytes obtain their food from decaying organic matter and examples are found in the mushrooms. Parasites obtain their food from living plants and animals and examples are found in rusts, smuts and most leaf-spots. The latter give rise to what are known as fungous diseases. Producing these diseases is a definite organism.

Parasitic fungi may attack the leaves, the stem, the root and the fruit. Areas of the living tissue are either damaged or killed. In some cases only part of an organ is attacked and the organ continues to function imperfectly. In other cases the entire organ is destroyed and leaves that have been attacked frequently fall from the plant prematurely. Infected fruits usually fail to develop normally and may be completely destroyed. Stems and branches may be seriously damaged by certain fungi and roots may be destroyed. In most cases plants

attacked by parasitic fungi are weakened and in some cases this becomes sufficiently great to endanger the life of the plant.

Most of the fungi that cause disease reproduce by spores. These spores are very tiny and serve for the distribution of the disease. Each disease has its own special spores. These are carried about by wind, rain, birds and other agencies and lodge in various places. Some of these lodge on parts of plants that are subject to the disease they are capable of producing. Germination is necessary for infection and, when conditions are favourable for their germination, they germinate or produce germ tubes. These very tiny thread-like germ tubes may enter the plant organ through the stomata or openings in the leaf for gas exchange, through the epidermis and through wounds. Once within the plant part, the threads grow rapidly, drawing nourishment from the plant and setting up a diseased condition of the organ. After gaining entrance to the host the organism cannot be destroyed without injuring the organ and the disease cannot be prevented. Exclusion of the organism is the only method of preventing the disease. To prevent the occurrence of the disease one must, therefore, prevent the organism from entering the plant. The leaves, twigs, fruit and other parts liable to infection must be coated with some agent that will prevent the germination of the spores or will destroy the germ tubes immediately after germination takes place and before entrance to the host has been gained. If this is done effectively, the disease will be controlled.

Bacterial Diseases.—Diseases caused by bacteria are known as bacterial diseases. A bacterium is a very simple organism consisting of a single cell that is very minute. The cell shows little differentiation, and a nucleus, as present in the majority of cells, is not visible. Bacteria differ greatly in shape and all lack chlorophyll. Some are motile while others are not. Most bacteria affecting plants gain entrance to the host through wounds.

Injury may be done to plants by bacteria in different ways. In some cases soft rots result from their attacks. In other cases they clog the tiny vessels through which the water and salts from the soil are carried to the various parts of the plant above-ground. Injury from bacterial diseases is usually serious and in most cases plants or parts of plants attacked die as a result.

Virus Diseases.—A virus disease is caused by an agent the nature of which is not known. No definite organism, as in bacterial and fungous diseases, has been found associated with diseases of this type. Yet when sap from a diseased

plant is injected into a healthy plant of the same kind, or of certain other kinds in some cases, disease develops in the latter. Mosaic, which occurs in many plants, and Aster Yellows are common examples of virus diseases. In the former case the plant is usually dwarfed and the foliage is not uniformly green as it is in healthy plants. Areas that are pale in colour and with a yellowish tint are found among those that are a normal green and a mosaic appearance results. In Aster Yellows the flowers or parts of them fail to develop their normal colour and the plants lack thriftiness. This type of disease is usually spread by sucking insects—insects that live on the juices of the plant. These insects visit both diseased plants and healthy plants. From the diseased plants they carry the agent to healthy plants and the latter become infected.

Physiological Diseases.—Diseases caused by nutritional disturbances are referred to as physiological. These are manifested in different ways but one of the most common manifestations of this type of disease is in the lack of the normal supply of green colouring matter in the leaves of plants that are normally green. A shortage in the green colouring matter results in a chlorotic condition of the leaves and in such a case the disease may be known as "Chlorosis". These diseases are traceable to the lack of some element or elements necessary in the normal and proper functioning of the organ or organs. The elements required may be present in the soil when the disease manifests itself but for some reason the plant is unable, in such cases, to use them.

Principles of protecting Plants against Injury by Pests and Diseases

The prevention of damage to plants by pests and diseases is accomplished by (1) use of resistant forms and resistant varieties and (2) use of special control measures.

Resistance in Control.—The use of resistant forms has been a factor in the control of pests in fruits in certain cases only. In the culture of the European grape a stock that is not subject to attack by the grape phylloxera is frequently used and the production of grapes of this species is rendered possible where it would not be so otherwise. Forms of the flowering currant, as a source of black currants, are being favoured in certain quarters in preference to the common black currant because of the apparent freedom of the fruit of the former from attacks by the yellow currant fruit fly.

Little has been accomplished in breeding fruit plants for resistance to attacks by pests. As far as fruits are concerned one variety appears to be as subject to attack as another variety of the same species. Hybridization offers opportunities, however; and progress has been made in obtaining high-quality wine grapes that are resistant in large measure to attacks of the grape phylloxera.

While little has been done in the breeding of plants for resistance to attacks by pests, much has been accomplished in breeding for resistance to disease. Agents causing disease appear to be more highly specialized than pests in some cases at least, and have variety preferences. In many plants varieties have been obtained that are able to resist a disease to which other varieties are susceptible and in such cases the application of special control measures has thus been made unnecessary.

Special Measures in Control.—Special control measures for pests and diseases may be either direct or indirect. Those used in the control of pests are: (1) following good cultural practices and (2) use of insecticides. Those used in the control of diseases are: (1) following good cultural practices, (2) removal of diseased plants or plant parts, (3) painting wounds with suitable agents, (4) supplying elements that are deficient and (5) use of fungicides.

Culture in relation to Injury by Pests and Diseases.—Much can be done in keeping pests and diseases from doing serious damage by following good cultural practices. Plants that are being well cared for are usually vigorous, and vigorous plants are less likely to suffer seriously from attacks by pests and diseases than are plants in a weakened condition.

The proper preparation of the soil, the use of fertilizers, the giving of good tillage and the provision of shelter are conducive to thriftiness and tend to fortify the plants against their enemies. The removal and destruction of dead tops, of dead leaves and of rubbish is good cultural practice and will frequently assist greatly in reducing the amount of injury caused by pests and diseases.

Removal of Plants or of their Parts.—The removal and destruction of diseased branches or diseased plants becomes an important measure in disease control. In Black Knot, which attacks plums, and in Fire-blight, which attacks apples, this treatment must be resorted to if control is to be effected. The branches must be removed at the proper times and the proper precautions must be taken to prevent further infection. In the case of mosaic in the red raspberry the

removal of the affected plant or plants removes the source of infection and prevents the further spread of the disease.

Wounds and Disease.—Wounds are usually a source of danger to the plant. Through wounds organisms of disease and organisms of decay may gain entrance and seriously injure or destroy the plant. When a branch is removed inner tissues are exposed and in many cases it is impossible for the plant to cover these with a protective layer before destructive organisms begin their deadly work. Bacteria frequently gain entrance through wounds and in plants subject to certain bacterial diseases open wounds may endanger the life of the plant.

Any wounds that must be made should be made at a time of the year when healing will take place rapidly. From the standpoint of healing the best time to prune woody plants is during the month of May. Early in May is preferable to late in May. Where wounds must be made at other times, more than normal care must be exercised in the treatment of the wounds. All wounds made should be made with a sharp tool to ensure a smooth surface and should be made in such a way as to permit the escape of free water from the surface.

Ordinarily wounds one-half inch in diameter and over made in woody plants should be given special treatment. Immediately after being made such wounds should be covered with grafting-wax. Only a thin layer is required and the wax should be made pliable before being used. One of the firmer waxes should be used to ensure some of the agent remaining over the wound on the warmest day during the summer. Melted parawax is sometimes employed and, while fairly satisfactory, it does not remain on the wound as well as grafting-wax. Paint also is used and gives fair results but it should not be used where grafting-wax is available.

In special cases even very small wounds should be treated in the manner outlined above. Where the plant is subject to diseases the organisms of which gain entrance through wounds all wounds should be coated with grafting-wax. Just prior to being covered with grafting-wax wounds in such cases should be sterilized with a solution of corrosive sublimate in water, made by dissolving one part of the chemical in one thousand parts of water. The surface is merely wet with this solution and the grafting-wax then applied.

Use of Salts in Physiological Diseases.—In certain physiological diseases relief can be obtained through the proper use of the elements wanting. Chlorosis, which results usually from a shortage of certain elements, may disappear after treat-

ments either with certain iron or certain manganese salts have been given. These are sometimes dissolved in water and the solution sprayed on the foliage. In some cases they are introduced either into the trunks or into the branches, while in other cases they are applied to the soil.

Use of Insecticides.—Insecticides are those agents used in the control of insect pests and other animal pests. These agents may be employed in various ways but the most important uses are in spraying, in dusting and in fumigation. In spraying, the substances are applied, either in solution or in suspension, to the part or parts of the plant to be protected. In dusting, the agents are applied in the dust form: while in fumigation the agent is used in the gaseous form.

The use of a suitable insecticide is essential to success in the control of pests. An insecticide that can be used in the successful control of all pests is not known at the present time. For one pest one insecticide must be used if the best results are to be obtained. For another pest the use of another insecticide is necessary for good results. This continues down through the long list of pests. An insecticide that could be used successfully for all the common pests would simplify greatly recommendations for control and would be a very welcome addition to the present list of agents used in this work, but one of this nature is not known at present. Until such a compound is discovered control must be effected through the employment of the numerous insecticides that have demonstrated special insecticidal values.

It is very important that insecticides be used at the proper times. Used at certain times insecticides are very effective in controlling pests, but if used at other times they may be of little or of no protection to the plant. In many cases delay in the use of an insecticide results in serious injury to the plant and not infrequently does a plant lose nearly all its foliage in two or three days' time. In other cases the period during which control can be effected is very brief and unless the measure required is applied at this time the injury cannot be prevented. In a few cases the control of pests can be effected over a long period but as this period advances control frequently becomes increasingly difficult.

Thoroughness in the use of an insecticide is essential to the complete control of pests. When the entire plant is infested, treatment of a part only may be little better than no treatment. Using the insecticide in such a way that only the upper surface of the leaf receives treatment when treatment of the lower surface is more important is a waste of time and of

materials. In most cases every part of the plant subject to infestation should receive treatment.

Temperature is an important factor in insect control. As a general rule the more active an insect is the more quickly the agent employed will act. Most insects are reasonably active at temperatures of 70° F. and above, and effective control may be expected when such temperatures obtain provided proper treatment is given. A general minimum temperature cannot be given as it is found that one insecticide will be effective at a given temperature while another insecticide will have little or no killing value at that temperature. The use of certain insecticides at excessive temperatures results in injury to the plant and due regard to the upper limit of safety in temperatures should be given in insect-control work.

Use of Fungicides.—Fungicides are those agents used in the control of fungous diseases. These agents may be used in spraying, in dusting, in fumigation, in sprinkling and in immersion and soaking treatments.

The use of suitable fungicides, the application of these fungicides at the proper times, and thoroughness in treatment all are necessary in the control of fungous diseases. It has been stated above that fungous diseases cannot be cured but prevention in the majority of cases is possible. If the disease is to be prevented all parts subject to infection must have a protective coating of a suitable fungicide during the infection period. This demands thoroughness in treatment, treatment before infection begins to take place and the use of a fungicide that will prevent the entrance of the organism causing the disease.

CHAPTER XXI

INSECTICIDES AND FUNGICIDES

INSECTICIDES

Classes of Insecticides.—The important classes of insecticides are as follows: (*a*) food poisons, (*b*) contact remedies, (*c*) repellents and (*d*) gases. Food poisons are those that contain poisonous substances and which, when eaten by the pest, will cause death by their toxic action. The poisons are primarily for pests that have biting mouth parts and that eat the foliage and other exposed parts of the plant. Contact remedies kill by contact and are used chiefly for those with piercing and sucking mouth parts and that feed on the juices of the plant. Such pests are not injured by food poisons because their food is drawn from the interior of the plant or its parts. In certain cases, however, contact remedies are used for pests with biting mouth parts. Where it is unsafe to use food poisons for pests with biting mouth parts certain contact remedies are frequently employed. Repellents are not intended to kill the pest but are used merely to repel it. An odour that is offensive to the pest is usually depended upon to give the desired result. Gases are used primarily for pests that cannot be reached readily by other means.

FOOD POISONS

The chief food poisons used are compounds of arsenic. Some of the compounds of arsenic can be used and some cannot. To be safe for use on plants an arsenical compound must be virtually insoluble in water. Solutions containing as little as 0·0002 per cent or one-five-thousandth of 1 per cent of arsenious oxide, are fatal to most plants. Certain hard waters have been found to break down ordinarily insoluble arsenical compounds and to set free sufficient arsenious oxide to injure plants. Water with twenty parts of chlorine to one million parts of water has been found dangerous to use with the acid form of lead arsenate, for instance. Being insoluble in water, food poisons containing arsenic form suspensions only when mixed with water for spraying purposes.

The most important food poisons used in the control of

garden pests are: (1) Paris Green, (2) lead arsenate, (3) calcium arsenate, (4) white arsenic and (5) hellebore.

(1) *Paris Green.*—Paris Green is probably the best-known food poison used in the control of pests attacking plants. It is a fine green powder that is insoluble in water but soluble in liquid ammonia. It is sometimes adulterated with road dust, gypsum, barium sulphate, barium carbonate and white arsenic. All but the last are insoluble in ammonia. The last can be detected under the microscope as it appears in the form of small white octahedral crystals. Poor grades of pure Paris Green are sometimes placed on the market and in these some water-soluble arsenious oxide is frequently present. Such grades are unsafe to use as a spray unless lime is added as recommended below.

Paris Green may be used either as a spray or in the dust form. As a spray it is mixed with water and is used at the strength of one ounce to six or seven gallons of water. The arsenical is difficult to wet and is mixed with a very small amount of water first. After the wetting is complete, mixing with the total amount of water is effected. As a safety measure, to prevent injury to the foliage from the possible use of an inferior grade of Paris Green, the operator should add to the mixture approximately six times as much hydrated lime as Paris Green used. The lime combines with any free arsenious oxide that is present and renders it harmless to the plant. Any uncombined lime that is present is harmless to the plant. A Paris Green spray should be made up just before it is to be used.

When used as a dust, Paris Green is mixed either with common flour or with air-slaked lime. One part of the arsenical is sufficient for twenty to twenty-five parts of the agent with which it is to be mixed. The two should be thoroughly mixed and application may be made either with a tin can having a finely perforated bottom or with a piece of cheese cotton or muslin. In the latter case the muslin or cheese cotton containing the mixture is shaken lightly over the plant to be treated.

Paris Green can be used safely with Bordeaux Mixture but not so with lime-sulphur sprays.

(2) *Lead Arsenate.*—Lead arsenate is not as well known as Paris Green but it is one of the best arsenicals for use in controlling pests on plants. There are two physical forms: (1) powder and (2) paste. The latter usually contains about 40 per cent moisture, though the amount ranges from 25 to 50 per cent. The former is more generally used than the paste.

because of the lower cost of transportation per pound of effective lead arsenate. The latter is usually the finer, however, and from the standpoint of efficiency it is the better. Both these forms are white in colour. Three kinds, chemically, are obtainable. These are: (1) acid, (2) neutral and (3) basic. The acid form contains approximately 30 per cent more of the active arsenical than does the neutral and approximately 40 per cent more than does the basic. The neutral and basic forms are considered to be the safer to employ, however, and are recommended especially where a combination of sprays is to be used and also where the water to be used is alkaline or very hard.

Lead arsenate is a very popular arsenical because (1) it sticks well, (2) it spreads easily and uniformly, (3) it is safe to use and (4) it is usable with certain sprays with which Paris Green cannot be used.

This arsenical also may be applied either as a spray or as a dust. As a spray the neutral and basic forms should be used at the rate of one ounce of the powder to a gallon of water. If the acid form is to be used the amount may be reduced one-fourth. Where the paste form is to be employed the amounts of the arsenical should be increased 40 per cent. For use as a dust the powder form of this arsenical is mixed with common flour and one part of the arsenical is sufficient for fifteen to twenty parts of flour. This mixture is merely dusted on the plants, preferably when the foliage is moist.

(3) *Calcium Arsenate.*—As in lead arsenate, calcium arsenate is obtainable in two physical forms, namely: (1) powder, and (2) paste. In the latter case about 50 per cent moisture is present. Three chemical forms are obtainable, namely: (1) acid, (2) neutral and (3) basic. The commercial article is usually basic. This arsenical also is white. It is a safer arsenical than Paris Green, though probably no more so than lead arsenate but is cheaper than the latter. It remains in suspension reasonably well and has adhesive qualities. It carries from 50 to 60 per cent more arsenic than does lead arsenate. This is a very satisfactory arsenical.

This arsenical may be used either as a spray or as a powder. Being stronger than lead arsenate it may be used in smaller quantities. The normal strength for a spray is one ounce of the powder to one and one-half gallons of water. For dusting it may be mixed with flour and one part of the agent is ample for twenty to twenty-five parts of flour.

(4) *White Arsenic.*—This is known as ratsbane, arsenious acid and arsenious oxide. It is white in colour and usually

occurs as fine crystals. It is only slightly soluble in cold water but sufficiently soluble to render it unfit for use on plants. Leaves on which it is used are destroyed both by the acid which it forms with water and by its toxic effect on plants. It is very toxic and is used extensively in the making of various arsenical compounds. It is used also in making poisoned bait for cutworms and grasshoppers. It is a very cheap arsenical and is very effective where it can be used.

(5) *Hellebore.*—This is a white powder made by grinding the roots of a plant known as the European White Hellebore (*Veratrum album*) and is a non-arsenical. When freshly prepared it contains a powerful alkaloid known as jervine which is poisonous. This alkaloid is lost quickly when the powder is left exposed to air. Hellebore must therefore be kept in airtight containers when not in use. It kills by poisoning and also by stopping up the breathing pores of the pest, though the former is the more important. It may be dusted on the plant dry or it may be applied as a spray. For dusting, one part may be mixed with two or three parts of flour; and for spraying, one ounce is used to each two gallons of water.

This agent is used in certain cases where ordinary food poisons cannot be used safely. Exposed parts of plants treated with hellebore may be used on the table safely two or three days after a treatment with the insecticide has been given.

Various other compounds are employed as food poisons among which are calcium arsenite, zinc arsenite, sodium fluoride and derris. The first two on this list are used on plants but are not as satisfactory as those discussed above. The third compound mentioned is a fine white powder employed in the control of ants and cockroaches in dwellings. The last is being used much in an experimental way in the control of certain vegetable and fruit pests and the results obtained are encouraging. Some of the compounds under a trade name are dependable and may be employed but the use of questionable compounds is discouraged.

CONTACT REMEDIES

Contact remedies kill by different means but the most common of these are: (1) suffocation as a result of the closing of the spiracles or breathing apertures of the insect, (2) through absorption of a compound that interferes seriously with the normal functioning of certain of the organs and

resulting in death and (3) through the caustic action of the compound on certain of the tissues of the pest.

The most important contact remedies are: (1) soap-wash, (2) tobacco, (3) hellebore, (4) pyrethrum, (5) sulphur, (6) corrosive sublimate, (7) glue, (8) oils and oil emulsions and (9) miscellaneous compounds.

(1) *Soap-wash.*—The best wash for use is made from a whale-oil soap. Whale-oil soap is made by dissolving eight ounces of potassium hydroxide in four quarts of water. The solution is then boiled and to the boiling solution is added one and one-seventh pints of fish-oil. The whole is boiled for two hours and is then allowed to cool. This is used at the rate of one ounce to one quart of water. Soft or cistern water is preferable to hard water for use with soap. The solution is usually sprayed on the plants to be treated but plants in pots may be inverted and the top submerged in the solution. This solution kills through forming films over the spiracles of the insect and cutting off the supply of oxygen. This is a standard remedy for plant-lice.

Where whale-oil soap is not available a good laundry soap may be used at the same strength. Ivory soap has been found very satisfactory and is recommended where a laundry soap is to be employed.

(2) *Tobacco.*—This is a standard remedy for plant-lice. Plant-lice are very sensitive to certain compounds in tobacco and these are absorbed readily through the body wall of the insect. From a mere wetting of their bodies with a very dilute solution of tobacco extract or from contact with tobacco smoke the pest absorbs sufficient of the active compounds to result in death.

Tobacco is used in various forms. The most common forms are: (*a*) a liquid extract and (*b*) tobacco waste and papers containing suitable tobacco compounds. The former is usually employed as a spray and is adapted to general use. The latter is burned slowly and is used chiefly under glass.

The most common and best known liquid extract of tobacco is "Black Leaf 40". This is a very reliable compound and is always of the same strength approximately. It is a dark-coloured liquid with the odour of an old and much-used pipe. For use it is diluted with water and one part of the tobacco extract is mixed with five hundred to eight hundred parts of water. To the resulting solution is added a good laundry soap of an amount equal to five or six times that of "Black Leaf 40". While fairly efficient alone with water this insecticide becomes more efficient with a small amount of

soap. The treatment must be given in such a way that every insect is wet with the solution. Either spraying or immersion is satisfactory.

Tobacco papers are burned slowly and are used according to directions on the container. Tobacco waste is moistened and is burned slowly.

(3) *Hellebore.*—Its use has been discussed under "Food Poisons".

(4) *Pyrethrum.*—This is sometimes known as Persian insect powder or as Dalmatian insect powder. It is a yellowish powder and is the pulverized flowers of plants of a certain species of pyrethrum. Its value is due to an oil which is poisonous to insects but harmless to human beings and higher animals. When exposed to air, pyrethrum soon loses its poisonous properties and when not in use it must be kept in air-tight containers. It may be used as a powder either alone or mixed with twice its own bulk of flour, or as a spray at the strength of one ounce to three gallons of water. This insecticide kills by contact mainly.

Various compounds containing extracts of pyrethrum are used as contact insecticides. These extracts are usually made either with petroleum ether or alcohol and are either combined or mixed with a suitable carrier. Some of the compounds resulting are known as pyrethrum soaps. According to recent work pyrethrum extracts tend to deteriorate fairly rapidly though some method of preventing this deterioration may be evolved eventually.

(5) *Sulphur.*—Sulphur may be used either merely as ordinary "flowers of sulphur" or in chemical combination with other compounds. In the uncombined state it may be used either dry, by merely being dusted on the plant, or as a spray. In combination it is usually employed as a spray.

When used as a dust ordinary sulphur or "flowers of sulphur" may be applied through the medium either of a tin can with many fine perforations in its bottom or of a piece of cheese cotton. In the latter case the powder is placed in an improvised bag made from cheese cotton and is merely shaken through the fine openings. Very finely divided sulphurs are on the market and for dusting these are considered superior to the ordinary kind.

As a spray "flowers of sulphur" is used with a solution of soap and water. Two ounces of good laundry soap are dissolved in one gallon of soft water and to this solution one ounce of sulphur is added. Sulphur is not soluble in the soap

and water solution and the mixture must be kept agitated while spraying is in progress.

Temperature is a very important factor in the use of sulphur as an insecticide. At temperatures below 70° F. this agent is frequently ineffective, and when the temperature is very high injury to the plant may result. Temperatures at which it can be used to the best advantage appear to lie between 70° F. and 85° F.

In combination sulphur is used with washing soda and also with lime. In the former case the two are fused at a high temperature and a sulphur compound that is more or less soluble in water results. This is merely dissolved in water and used as a spray. It is a very convenient form of sulphur and is used extensively in pest control.

Combination of sulphur with lime is effected in different ways, but the most common is that of boiling together water, freshly slaked lime and sulphur. With each forty imperial gallons of water are used fifty pounds of fresh stone lime and one hundred pounds of sulphur. The lime is slaked in just sufficient water to slake it. The required amounts of water and of sulphur are then added and the whole mixture is boiled for one hour. The resulting solution is diluted to the proper strength for spraying purposes. For use on dormant wood before the buds open, the solution may test 1·035 specific gravity, while for use on plants in leaf it is usually diluted to test about 1·008. The compounds resulting from this boiling are numerous, but the most important are the calcium sulphides. This spray is effective as an insecticide through (*a*) its caustic action and (*b*) its ability to form a layer more or less impervious to oxygen and thus to suffocate certain pests.

(6) *Corrosive Sublimate.*—This is a fine white powder slowly soluble in cold water but readily soluble in hot water. It is a powerful irritant and is very poisonous. As an insecticide it is used in the control of certain pests that are present in the soil and that attack the roots of plants and also in the treatment of gladiolus corms for thrips. For use in most cases it is dissolved in hot water at the rate of one ounce to eight gallons of water. For the control of pests in the soil the solution is applied to the soil and, for thrips on the gladiolus, the corms are soaked in the solution for a suitable period. For thrips on corms of the gladiolus it is used at the rate of one ounce to six gallons of water. Through its irritating action this agent destroys the pests for which it is used.

(7) *Glue.*—Glue is not ordinarily regarded as an insecticide

but it has insecticidal value. This agent has been used successfully in the control of red spider. For use it is dissolved in water at the rate of one pound to ten gallons of water, and the solution is sprayed on the infested plants in such a way that the under-surface of the leaf, where the pest is found, is well coated with the spray. This spray sticks the mites to the leaf and death of the pest results in a short time.

(8) *Oils and Oil Emulsions.*—The chief insecticides used under this heading are: crude petroleum, kerosene emulsions and lubricating oil emulsions.

The use of crude petroleum has resulted in certain cases in serious damage to the plants on which it has been sprayed. When emulsified and diluted with water, however, it appears to be a safe insecticide and of value in the control of certain pests. Other oil emulsions are probably preferable in most cases.

Kerosene emulsions have a wider use than crude petroleum and have been used for many years. Occasionally damage to plants results from their use, but the injury is usually traceable to the improper making or the improper use of the agent. A simple and easily made kerosene emulsion is prepared as follows:

Kerosene (ordinary coal oil) . . .	1 gallon
Rain water	½ ,,
Soap	4 ounces

The water is heated to the boiling point and into this boiling water the soap is sliced. Boiling is continued until all the soap is dissolved. While boiling hot this solution is mixed with the kerosene. The mixture is churned vigorously for five minutes. The use of a sprayer to break up the mixture into very small particles is an aid. This should result in an emulsion of a smooth, creamy nature and on cooling it should be a jelly-like mass. This emulsion is diluted with water for use and is usually made up to fifty gallons of spray. It may be diluted less or more than this as conditions demand it.

Various formulae are used successfully in the making of lubricating oil emulsions but one of the most common is as follows:

Lubricating oil (medium) . .	1 quart
Copper sulphate (bluestone) . .	½ ounce
Hydrated lime	1 ,,

The copper sulphate is dissolved in a small amount of hot water and the solution is then made up to one half-quart.

The lime is mixed with one half-quart of water. The copper and lime solution are then poured at the same time into another container. This results in one quart of standard Bordeaux Mixture. To this mixture is added one quart of lubricating oil. The two are then mixed vigorously until an emulsion results. A small pump or an egg-beater may be used to aid in the emulsification of the oil. The resulting emulsion is then mixed with water to make ten gallons.

(9) *Miscellaneous Compounds.*—Many of these are on the market under various names. Some are effective and are safe agents to use while others may be considered questionable. In many cases standard insecticides are merely disguised and sold at much higher prices than those for which such insecticides can be obtained in the usual form. Before using compounds that are not recognized as insecticides the grower should make certain that the agent will give the desired results and will not injure his plants.

Repellents

The most important repellents used in the control of pests are creosote, coal-tar and carbolic acid. These are employed in different ways. In some cases the seed is coated with the agent. In other cases a ribbon of the agent is placed on the ground in front of the marching hordes of pests and around a field in crop to protect the crop from devastation.

This class of insecticides is of little importance in pest control in western Canada at the present time. In few cases it is necessary to resort to this means of protecting plants against pests in prairie regions. Where used these compounds are effective, however, and it is very probable that their use will become necessary in this region at some time in the future.

Gases

Gases have limited use in pest control. Owing to the necessity of having the gas confined and at a lethal concentration this class of agent is seldom used in the open. Such agents are frequently employed, however, in controlling soil pests and certain pests in buildings. In some cases trees in the open are given a treatment with gas by placing a tight tent over the plant and releasing the gas in the tent but this is practicable under very special conditions only.

Important gases used as insecticides are as follows: (*a*)

carbon bisulphide, (*b*) carbon tetrachloride and its mixtures, (*c*) hydrocyanic acid gas, (*d*) sulphur fumes, (*e*) napthalene, (*f*) paradichlorobenzene and (*g*) tobacco punks.

(a) *Carbon Bisulphide.*—This is a vile-smelling liquid that volatilizes readily. The vapours are slightly over two and one-half times as heavy as air, are very poisonous and ignite at 297·5° F. One part of the gas in 14·3 volumes of air forms a very explosive mixture.

Carbon bisulphide is used in fumigating buildings, in controlling certain soil insects and in dealing with grain weevils. In the first case it is used at the rate of five to eight pints per thousand cubic feet of space and the fumigation is continued for twenty-four hours. About one pound is required for each one hundred bushels of grain to be treated and the treatment must be given in a tight room. The amounts used for soil treatments depend upon the kind of pest and the conditions under which it is used. This gas must be used at temperatures of 70° F. or over. Care must be exercised when using it in closed buildings to avoid explosions.

(b) *Carbon Tetrachloride.*—This agent is used both alone and in combination either with ethyl acetate or with ethylene dichloride. Carbon tetrachloride is a colourless liquid that vapourizes readily. The vapours are non-inflammable, non-explosive and heavier than air. They are lethal to insects and harmless to human beings unless inhaled in large amounts. This agent is used at the rate of fifteen to twenty pounds per one thousand cubic feet of space to be treated and the treatment is continued for twenty-four hours. The temperature of the room should be about 70° F.

One mixture consists of one part by volume of liquid ethyl acetate and one and one-half parts by volume of carbon tetrachloride and the other consists of three parts by volume of ethylene dichloride and one part by volume of carbon tetrachloride. These are used in confined quarters at the rate of fourteen pounds to each one thousand cubic feet of space. They are used in treating insects attacking furniture and clothes and also for certain pests attacking stored plant parts.

(c) *Hydrocyanic Acid Gas.*—Though deadly this is a very widely used gas. It is employed in the fumigation of greenhouses for plant pests, dwelling houses for domestic pests, flour mills for flour and meal moths and other buildings for certain other pests. It has an important use in the treatment of dormant nursery stock that is passing from one state to another or from one country to another. It is used also to some extent in the control of certain soil pests.

This gas is colourless with an almond-like odour and is about seven-tenths as heavy as air. It is very soluble in water, has a boiling point of 26·5° C. and can be liquefied easily. It is very poisonous to animal life and plants will tolerate only a limited concentration of the gas.

Tight enclosures are necessary for the successful use of this gas. While used to some extent out-of-doors inside tents placed over the plants to be treated it is used chiefly indoors. Buildings being fumigated must be vacated for a period of twenty-four hours at least.

The source of this gas is some compound containing cyanide. The usual source is either sodium or potassium cyanide and the gas is released from these salts by sulphuric acid and water. This gives rapid evolution of gas and a high concentration is obtained in a short time. This is the most common manner of obtaining this gas.

Sodium cyanide is approximately 30 per cent stronger than potassium cyanide and less of the former than of the latter is required, in a given case. The proportions of acid, water and cyanide required are as follows:

(*a*) Where sodium cyanide is to be used—

Sodium cyanide	1 ounce
Sulphuric acid (strong) . . .	1½ fluid ounces
Water	3 „ „

(*b*) Where potassium cyanide is to be used—

Potassium cyanide	1 ounce
Sulphuric acid (strong) . . .	1 fluid ounce
Water	3 „ ounces

The amounts of sodium cyanide required for each one thousand cubic feet of space are as follows:

(1) For greenhouses containing growing plants . ¼-½ ounce
(2) For dwelling-houses and other buildings . . 16 ounces

Where potassium cyanide is to be used the amounts should be increased about one-third and where calcium cyanide is to be used the amounts should be doubled. Tight greenhouses require less than do those poorly constructed, and it is advisable to start with the smaller amount mentioned. If this is not found sufficient a small increase in the amount should be made until the minimum required to kill the pests has been reached.

The building must be properly prepared before the fumigation is begun. All windows must be tightly closed and

all openings that would permit the escape of gas freely should be sealed. Any moist foods or fluids for drinking purposes in the building that are to be used later must be removed, as these will absorb sufficient of the gas during the fumigation period to render them unfit for use later. The leaves and stems of plants in a greenhouse that is being fumigated should be dry, and any watering that is required should be done at least a few hours before the gassing is started. Before the fumigation begins, in the case of buildings occupied by human beings, a thorough search should be made to make sure that no one is in and a proper warning sign should be conspicuously displayed on the outside of the door. The building must be vacated even if only one room is being fumigated. Provision should be made for the opening of some of the windows from the outside so that the building can be ventilated before being re-entered.

Where treatments with sodium cyanide and potassium cyanide are to be given several containers are necessary. In the case of a greenhouse of average size five or six containers should be used and these are well distributed over the area. These containers need not be large, and those with a capacity of one to two quarts should be satisfactory. Since the acid is strongly corrosive either earthen or glass vessels should be used. The required amounts of the three components are first weighed and measured out. The acid is poured slowly into the water and the solution stirred. The solution is then divided equally among the containers being used. The cyanide is then divided into the same number of equal portions and each is wrapped with two thicknesses of newspaper. When everything is in readiness the operator starts at the container most distant from the exit door, dropping one parcel into each container and working toward the exit as rapidly as possible. The fumes must not be inhaled and care must be exercised both when weighing out the salt and distributing it in the building being fumigated. The door is closed at once and the building left closed for twelve hours. Before being re-entered the building should be aired well.

(e) *Naphthalene.*—This is obtained usually in the form of flakes. The flakes are usually employed alone, but they are sometimes mixed with either cedar chips or lavender flowers. The fumes are given off slowly and when sufficiently concentrated they are lethal to insects. This agent is used among clothes against clothes moths and also in the control of certain other pests. Its chief use is in small quarters. Naphthalene is the active principle of moth-balls.

(f) *Paradichlorobenzene.*—This is a white cystalline powder that vaporizes slowly at ordinary temperatures. The gas is non-inflammable and non-poisonous to human beings but is toxic to insects. It is heavier than air.

This agent is used in the control of certain pests attacking fruit trees, certain soil insects and also clothes' moths. In the last case it is used as a substitute for naphthalene. In the first case the pests concerned attack the tree just at or above the ground surface and bore into the trunk. The chemical is distributed around the trunk and about two inches from it, one ounce being used for each tree. The crystals are placed either on a level with the tunnels made by the pests or just above them. An inch or two of clean dry soil is then placed over the crystals and around the trunk of the tree. The fumes kill the pests in five days to three weeks, depending upon the temperature and the activity of the insect. At the higher temperatures the shorter periods are sufficient.

(g) *Tobacco Punks.*—Papers impregnated with strong tobacco infusions and moistened tobacco stems and tobacco dust are used in fumigation to some extent, especially in greenhouses. The greenhouse is made as tight as possible and definite amounts of these materials are burned slowly. The fumes resulting become distributed throughout the house and pests sensitive to tobacco compounds are destroyed.

Fungicides

The most important fungicides used are as follows: (*a*) sulphur, (*b*) Bordeaux Mixture, (*c*) potassium sulphide, (*d*) formaldehyde, (*e*) corrosive sublimate, (*f*) copper carbonate, (*g*) organic mercury compounds and (*h*) miscellaneous compounds.

(a) *Sulphur.*—This has been discussed under insecticides and little further need be stated here. It is an excellent fungicide in certain cases and for over one hundred years it has been the standard remedy for "Powdery Mildew". As a fungicide it is employed both uncombined and in combination and is used in the various ways outlined above.

Lead arsenate and calcium arsenate, as insecticides, may be combined with sulphur sprays being used as fungicides. Paris Green, however, must not be used with sulphur sprays.

(b) *Bordeaux Mixture.*—This spray was first used in the vineyards around Bordeaux, France, and obtains its name from its place of origin. It was first used in 1885 as a remedy for Downy Mildew on the grape. It is still used in the control

of this disease and it has a wide use in the control of other diseases.

While various formulae are used in its preparation, Bordeaux Mixture is usually made at the present time according to a formula as follows:

Copper sulphate (bluestone) . .	1 pound
Hydrated lime	2 pounds
Water	10 gallons

The bluestone is dissolved in a small amount of hot water in a wooden or earthenware vessel, the latter preferably. Copper and brass receptacles also may be used. The best plan is to place the bluestone in a sack and then to suspend the sack with its contents in the hot water. The pulverized form dissolves more readily than large crystals and is preferable to the latter. After solution is complete, water is added to make up one-half the total amount of the spray. The hydrated lime is mixed with a small amount of water until thoroughly wet. This is then diluted with water and made up to half the total amount. This should be run through a fine strainer to remove particles that would clog spray-nozzles. The two solutions—bluestone and lime—in the fully diluted condition are poured at the same time into the spray barrel or some other container. This results in the formation of Bordeaux Mixture. A precipitate is formed when the two solutions are mixed but this is very fine and remains in suspension for considerable time.

Freshly burned stone lime may be used in place of hydrated lime and when this is to be used one and one-half pounds to ten gallons of water are sufficient. This is slaked in just enough hot water to slake it and then water is added to make five gallons. The bluestone and lime solutions are brought together after the straining of the latter as in the previous case.

A great excess of lime is used in the making of Bordeaux Mixture. Copper sulphate solutions are acid and when employed alone at the strength given above they burn the foliage of plants. Before it can be used copper sulphate must be changed to a form that will not injure the plants. Lime is the agent used to render the copper sulphate harmless to the foliage. It combines with the latter compound and precipitates the copper. The precipitate is virtually insoluble in water. Ordinarily one-fourth of the lime used, or a little more, will precipitate all the copper, and the remainder is unchanged. This excess of lime is used to ensure against the burning of the foliage where the lime is of poor quality. While it slows up the action of the fungicide, an excess of lime is a safeguard,

and usually prevents minor injuries such as the russeting of leaves and fruit and the yellowing and dropping of leaves prematurely.

Before being used Bordeaux Mixture should be tested for soluble copper. A very sensitive test is made with a solution of potassium ferrocyanide. A suitable solution of potassium ferrocyanide for use is made by dissolving one-fourth of an ounce of the chemical in three ounces of clear rain-water. An ounce of the clear fluid from the top of the mixture to be tested is placed in a shallow dish. Into this are placed a few drops of the potassium ferrocyanide solution. If any free copper is present a reddish brown precipitate results and the mixture is unsafe for use. More lime must be added in this case. If no precipitate results the mixture can be used safely. The potassium ferrocyanide solution is highly poisonous and should be handled accordingly.

Certain precautions should be used in making and handling Bordeaux Mixture. Neither the copper sulphate solution nor Bordeaux Mixture should come in contact with metals other than brass and copper. Even the sprayer should be of one of these metals. It is very important that the lime solution and the copper sulphate solution be fully diluted before being brought together. When this is done the precipitate formed is fine and a good product results. Where the concentrated solutions are brought together, and the dilution given afterward, a coarse precipitate is found and a poor product results. Good lime must be used and the potassium ferrocyanide test should be made before the mixture is applied to plants. The mixture should not come in contact with bare hands any more than is necessary, as it has a hardening and drying action on skin.

Bordeaux Mixture may be used safely with Paris Green, lead arsenate and calcium arsenate.

(c) *Potassium Sulphide.*—This is a dark-coloured crystal that is readily soluble in water. It is used at the strength of one ounce of the crystal to one and one-half gallons of water. Solutions of this are corrosive and should not be allowed to come in contact with metal for longer periods than are necessary. Preparation of the spray should take place just before it is to be used, as the solution loses virtue on standing. It is used frequently in the control of powdery mildew on currants and gooseberries.

(d) *Formaldehyde.*—This is a gas at ordinary temperatures. At very low temperatures it condenses and forms a clear liquid. Formalin is a mixture of this liquid and water in the

proportion of 40 per cent of the former and 60 per cent of the latter by volume.

This fungicide is used in treating seed grains for smut and seed potatoes for common potato scab. For soaking treatments it is usually employed at the rate of one pint to forty gallons of water and for sprinkling treatments one pint to ten gallons of water.

This agent is used also in treating soil for the control of certain soil organisms. It is used both with water and as a dust. The soil is either wet thoroughly with the solution or the dry form is mixed with the soil. The usual rate of application of formalin is two quarts of a 2 per cent solution in water per square foot of soil. Several days must elapse after treatment before seeds may be sown or plants transplanted to the soil thus treated. A period of ten days to two weeks is usually ample.

(e) *Corrosive Sublimate.*—Reference has been made to this as a contact insecticide. It is used as a fungicide also in solution in water usually at the strength of one ounce of the chemical to eight gallons of water.

Its chief uses in the control of disease are in the treatment of seed potatoes for Common Scab and Black Scurf and in the sterilization of wounds and tools.

(f) *Copper Carbonate.*—This is a powder that is light green in colour, is fine and should be without gritty particles. Its chief use is in treating grains for smut. It is used also on seeds in special cases as a repellent against mice and certain insects.

(g) *Organic Mercury Compounds.*—A number of these have been used during recent years and have given satisfaction. Probably the best known are Semeson, Ceresan and Upsulin. Leytosan has appeared recently and great claims for it are made. These are fine powders and are used either dry or with water. They are used in treating seeds prior to planting and also in treating soil. In the control of "Damping Off" and of certain other diseases they have proved to be of considerable value. Seedlings of certain plants, however, react unfavourably to treatments with these compounds and the user should follow carefully the directions supplied by the manufacturer.

(h) *Miscellaneous Compounds.*—Certain other compounds are being used in the control of disease. Some of these are marketed under trade names and some are not. Among these is red oxide of copper which has been found to be of great value in the treating of seeds for the control of "Damping Off". However, only those that have been well tried and have proved to be safe and satisfactory should be employed.

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